SPACER PAGE
POWERPLANT
STUDENT HANDOUT
PART TWO

CLASSIFICATION OF LUBRICANTS

ANIMAL

VEGETABLE

MINERAL

SYNTHETIC

04-94-50

NOTES

A. Lubricating oils

1. A lubricant is any natural or artificial substance having greasy or oily properties which can be used to reduce friction between moving parts or to prevent rust or corrosion on metallic surfaces.

2. Lubricants may be classified according to their origins as animal, vegetable, mineral, or synthetic.

3. Lubricants of animal and vegetable origin are chemically unstable at high temperatures, often perform poorly at low temperatures, and are unsuited for aircraft engine lubrication.

4. Lubricants having a mineral base are chemically stable at moderately high temperatures, perform well at low temperatures, and are widely used in aircraft engines.

WARNING

When handling oil used in gas turbine engines, do not allow oil to remain on skin any longer than necessary. It contains a toxic additive that is readily absorbed through skin.

5. Synthetic lubricants

a. Synthetic lubricants are not refined from natural crude oils like mineral lubricants, instead synthetic lubricants are chemically manufactured.

b. Typical synthetic lubricants are the Type I, alkyl diester oils (MIL-L-7808); and the Type II, polyol ester oils (MIL-L-23699).

6. Because of the high temperature required in the operation of gas turbine engines, a lubricant is required that retains its characteristics at high temperatures that would cause petroleum lubricants to evaporate and break down into heavy hydrocarbons. Synthetic oils do not break down easily and do not produce coke or other deposits. However, synthetic oils are likely to dissolve paints and should be removed immediately if spilled on a painted surface.

B. Lubricating oil requirements

1. The conditions in which the engine operates determines the requirements for the lubricating oil.

2. Desirable lubricating oil qualities are viscosity, anti-friction ability, cooling ability, and chemical stability.

3. TM 55-1520-238-23-1 and TM 55-1520-238-10 specify the engine oils for use in the AH-64A.

FUNCTIONS OF ENGINE OIL

- REDUCES FRICTION BETWEEN MOVING PARTS
- COOLS THE ENGINE
- SEALS MATING SURFACES
- CLEANS THE ENGINE
- PREVENTS CORROSION
- CUSHIONS IMPACT LOADS BETWEEN PARTS

04-94-51

NOTES

C. Engine oil does more than lubricate internal engine components. Engine oil performs these functions:

1. It lubricates, thus reducing the friction between moving parts.

2. It cools the various parts of the engine.

3. It tends to seal mating surfaces, and the film of oil on various surfaces is an effective pressure seal.

4. It cleans the engine.

5. It aids in preventing corrosion by protecting the metal from oxygen, water, and other corrosive agents.

6. It serves as a cushion between parts where impact loads are involved. The oil cushions bearing surfaces by absorbing the shock between them.

MIL-L-23699 AND MIL-L-7808

MIL-L-23699	MIL-L-7808
• SYNTHETIC	• SYNTHETIC
• USE IN OUTSIDE AIR TEMPERATURES OF -25°F (-32°C) AND ABOVE	• USE IN OUTSIDE AIR TEMPERATURES OF -25°F (-32°C) AND BELOW

04-94-52

NOTES

D. Turbine engine oils MIL-L-23699 and MIL-L-7808

1. MIL-L-23699 has a greater life than MIL-L-7808 and has generally replaced MIL-L-7808. This is the recommended oil for all new and overhauled turbine engines.

2. MIL-L-7808 is used in extreme low temperature ranges.

3. There is no easy way to look at oil and tell the difference between the two types. The only way to determine which type of oil is in an engine is by careful maintenance and examination of servicing records.

4. MIL-L-7808 and MIL-L-23699 are required by specifications to be compatible with each other. However, adding MIL-L-7808 oil to a system that requires MIL-L-23699 should be avoided, if possible, since the addition of MIL-L-7808 oil lowers the concentration of MIL-L-23699 oil and thus tends to nullify the benefits derived from the MIL-L-23699 oil.

   a. Indiscriminate mixing of the two oils may result in pressures and flow limits different from the published values for either oil.

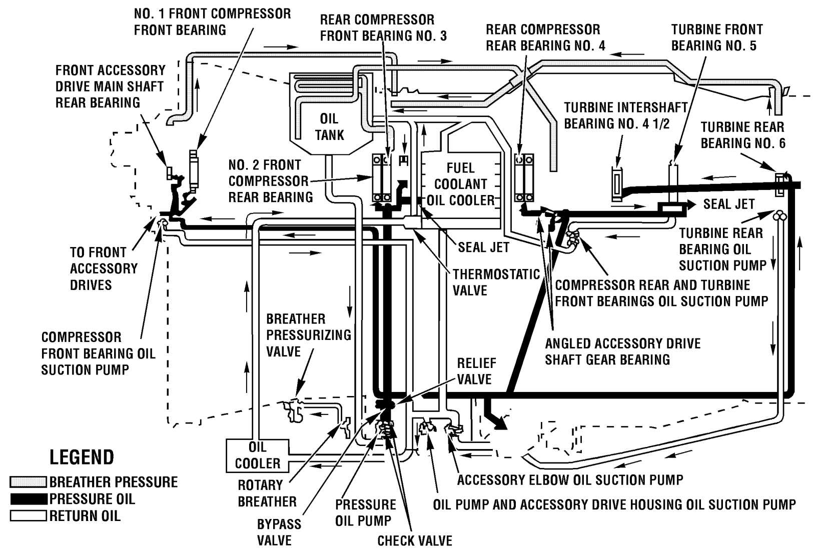
   b. When operating conditions necessitate servicing with MIL-L-7808, the system or components should be drained and re-serviced with MIL-L-23699 as soon as conditions permit.

E. Oil sumps

1. In turbine engine lubrication systems, the oil supply is contained in a reservoir.

2. The classification of an engines lubrication system as wet-sump or dry-sump denotes the location of its oil reservoir.

DRY SUMP LUBRICATION SYSTEM



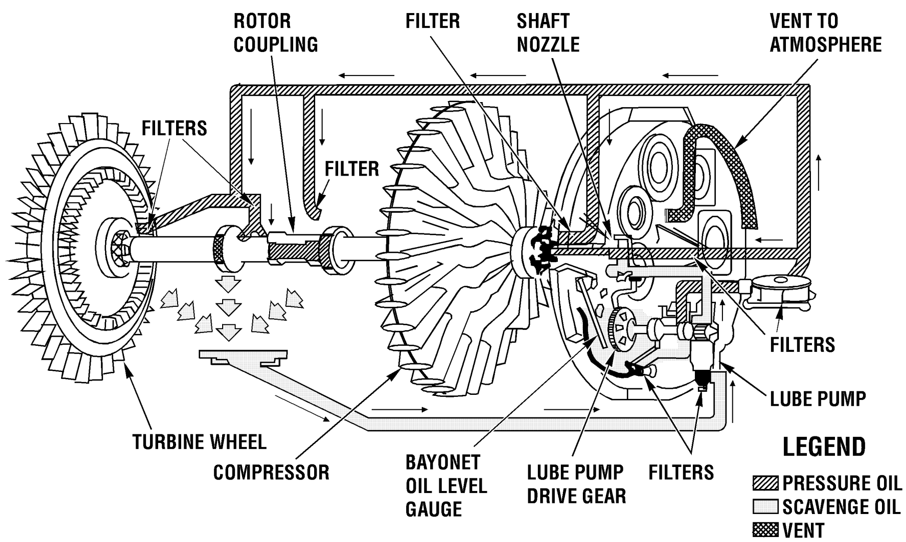
DRY SUMP LUBRICATION SYSTEM FOR TURBINE ENGINES

04-94-53

NOTES

a. Dry-sump - In a turbine dry-sump lubrication system, the oil supply is carried in a tank mounted externally on or near the engine. With this type of system, a larger oil supply can be carried and the oil temperature can be controlled.

WET SUMP LUBRICATION SYSTEM



WET SUMP LUBRICATION SYSTEM FOR TURBINE ENGINES

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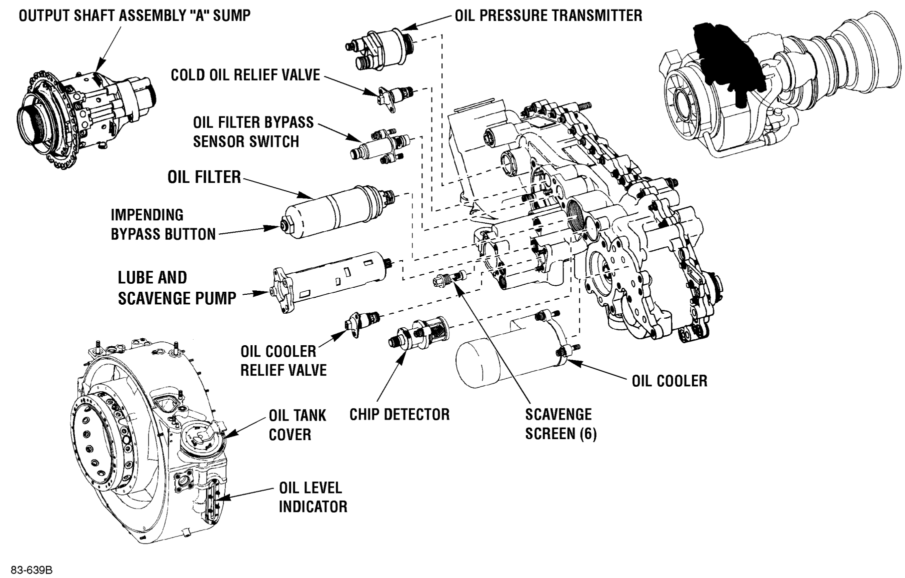
NOTES

b. Wet sump - Reservoirs for wet-sump systems are an integral part of the engine and contain the bulk of the engine oil supply.

LUBRICATION SYSTEM COMPONENTS



NOTES

F. T700-GE-701/701C lubrication system

1. The lubrication system distributes oil to all the lubricated parts, and in emergencies, supplies an air-oil mist to the main shaft bearings in the A and B sumps.

2. The system is a self-contained, recirculating dry sump system.

3. The lubrication system includes the following components.

   a. Lube and scavenge pump

   b. Scavenge screens (6)

   c. Oil filter

   d. Oil filter bypass sensor switch

   e. Cold oil relief valve

   f. Oil pressure transmitter

   g. Sumps

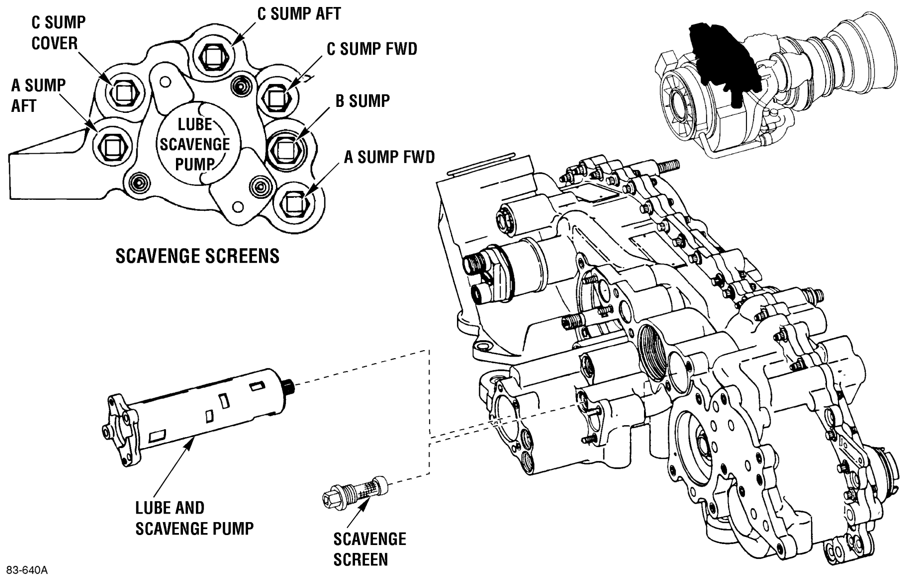
   h. Chip Detector

   i. Oil cooler

   j. Oil cooler relief valve

   k. Oil tank

LUBRICATION AND SCAVENGE PUMP



NOTES

G. Component characteristics

1. Lubrication and scavenge pump

a. Provides pressurized oil to the engine components that require oil.

b. Located on the forward side of the engine accessory gearbox.

c. A seven element gerotor type pump with one pressure element, and six scavenge elements.

d. The gerotor elements are arranged in tandem on a common drive shaft.

(1) Inner gerotors are keyed to the driveshaft.

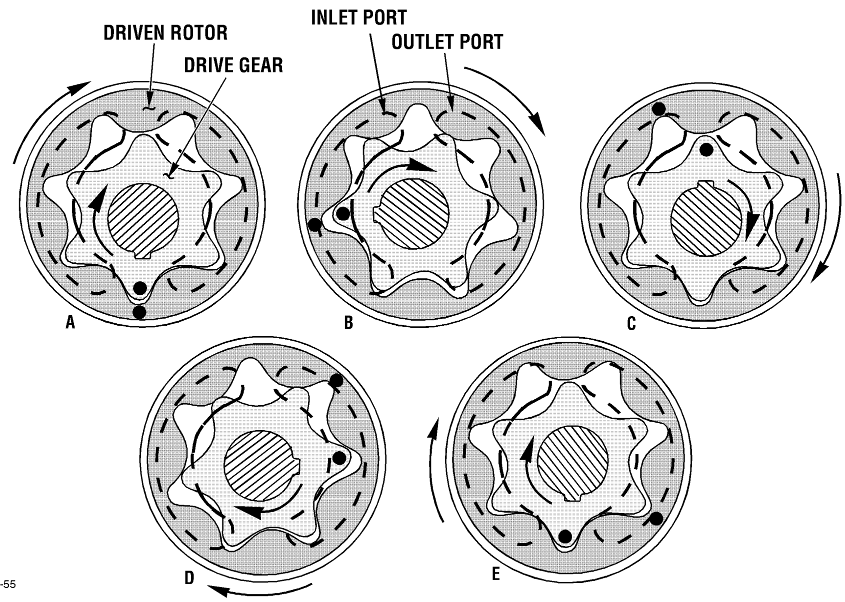
(2) Outer gerotors are pocketed in individual eccentric rings.

e. 25 - 55 PSI at idle

f. 45 - 100 PSI at 100% N_P

g. Scavenges oil from the sumps.

GEROTOR-TYPE OIL PUMP



NOTES

h. "Gerotor" principle

(1) The term "Gerotor" means generated rotor, and is the trade name for a very popular internal gear element.

(2) The slide shows a cross-section of a typical Gerotor element, which consists of a pair of gear shaped elements.

(a) The internal gear (or rotor) drives the outer gear in the same direction of rotation.

(b) The inner gear always has one less tooth than the outer gear.

(c) The pumping chambers are formed by the adjacent pairs of teeth which are constantly in contact with the outer element.

(3) As the inner gear is turned, it's gear tips precisely follow the contour of the outer element.

(a) Expanding chambers are created on the left as the inner gear's teeth withdraw from the outer gear's bottom lands.

(b) During the second half of the revolution, the chambers collapse, forcing fluid flow from the pump's outlet.

i. "Gerotor" pump operation

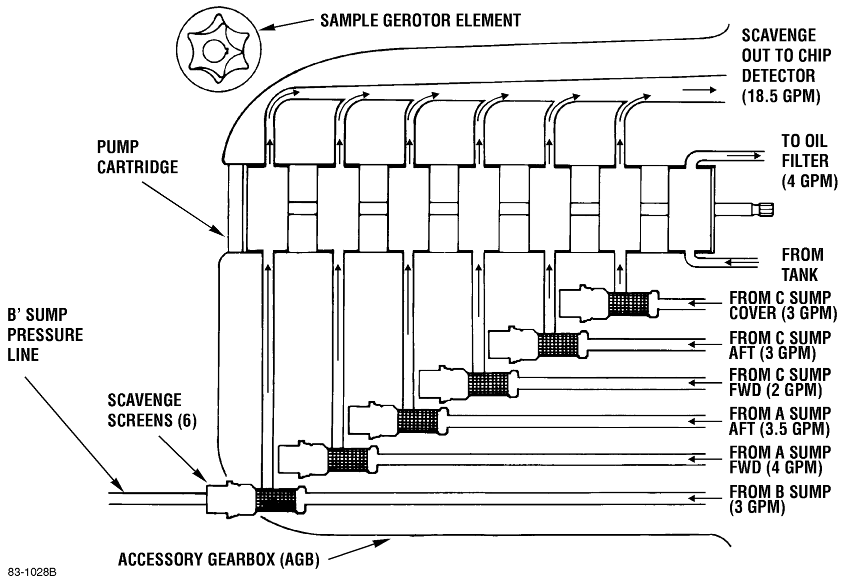
(1) In view A, the two marked teeth are meshed and there is a minimum of space between them.

(2) As the two gears rotate, the volume between the teeth increases as the marked teeth are followed in views A, B, and C.

(3) A plate with two kidney-shaped openings covers the gears, forming a seal for their ends.

(4) As the gears rotate beneath the inlet port, the volume between the teeth continually increases, and as they rotate beneath the outlet port, as seen in views D and E, the volume decreases, moving the fluid out into the system.

LUBRICATION AND SCAVENGE PUMP OPERATION



NOTES

j. Lubrication and scavenge pump operation

(1) One supply (pressure) pump element.

(2) Two scavenge (return) pump elements for the A-sump.

(3) One scavenge (return) pump element for the B-sump.

(4) Three scavenge (return) pump elements for the C-sump.

2. Scavenge screens

a. The scavenge screens collect large particles before they enter the sumps.

b. Six scavenge screens are located on the front of the accessory gearbox. These screens prevent damage to the pump.

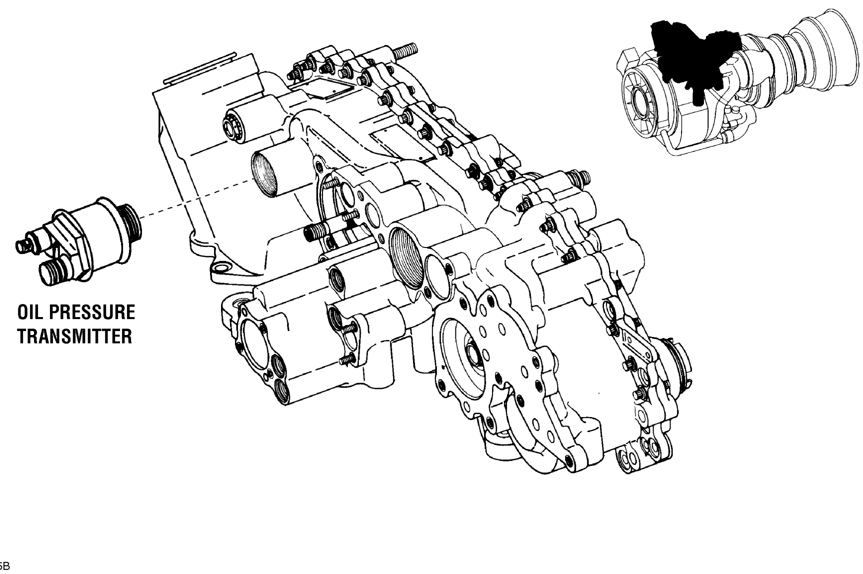
c. Aids in fault isolation

(1) Screens may be removed for inspection if chip generation is suspected.

(2) Screens are individually labeled to show which sump the particles came from.

d. B-sump screen has a hose routed to oil pressure transmitter.

OIL PRESSURE TRANSMITTER



NOTES

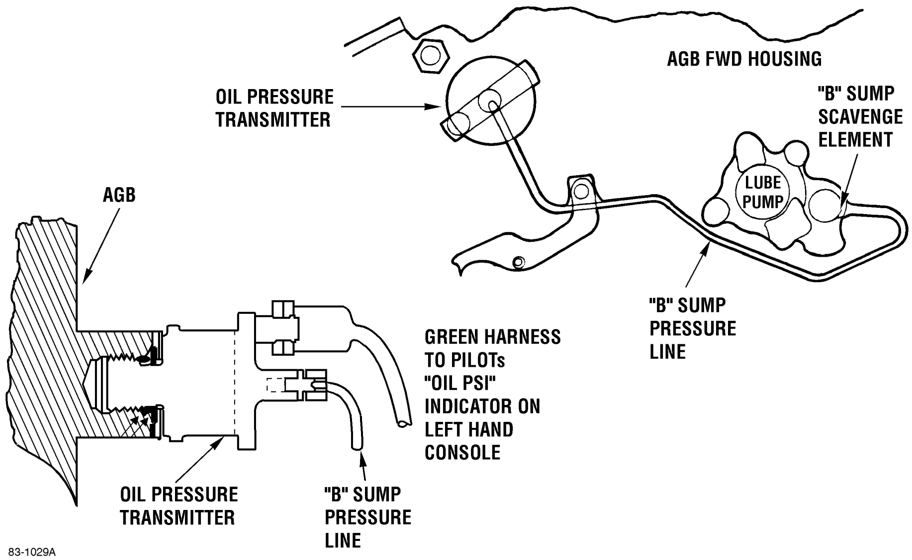
3. Oil pressure transmitter

   a. Provides an oil pressure indication to the pilot's engine oil pressure indicator.

   b. Mounted on the front of the engine accessory gearbox.

   c. A variable reluctance type transmitter.

OIL PRESSURE TRANSMITTER OPERATION

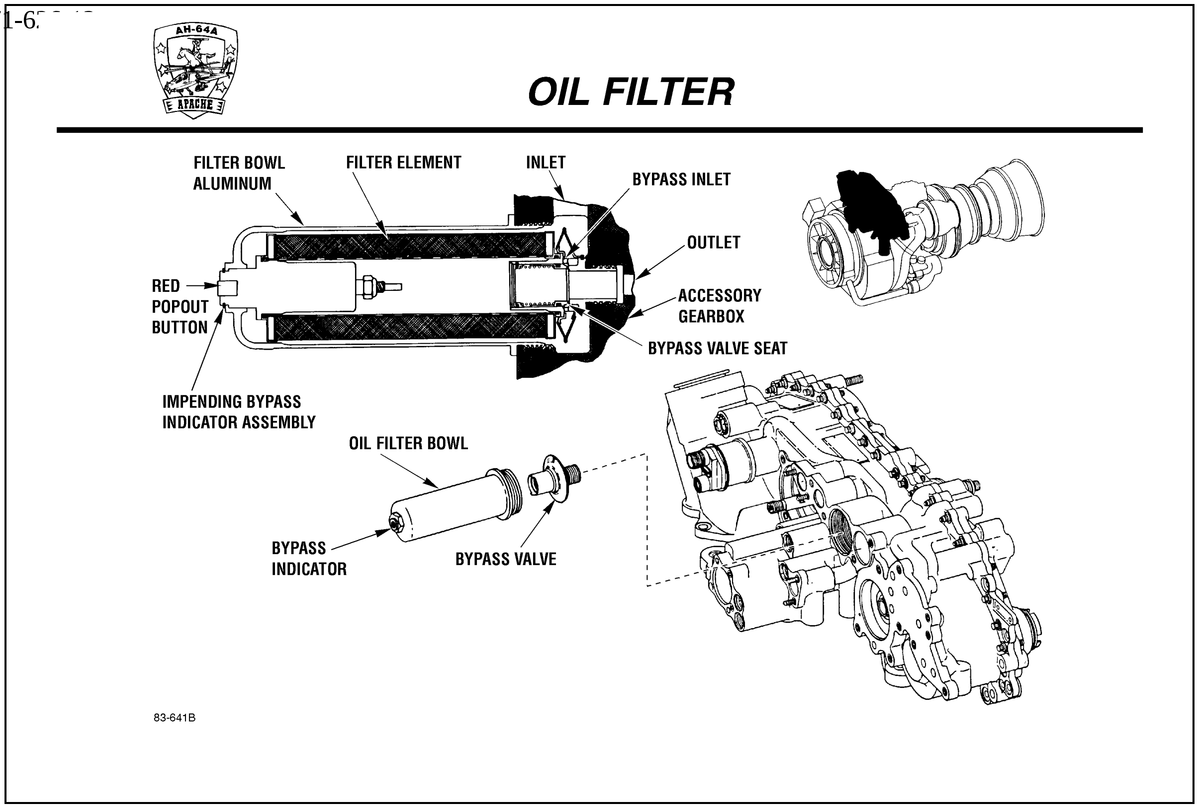


NOTES

d. Oil pressure transmitter operation

(1) The pressure indicated by the transmitter is B-sump differential pressure.

(2) B-sump differential pressure is used because a pressure indicating system reading only supply pressure does not show a drop in oil pressure until the supply side has run out of oil.


AH-64A
APACHE
OIL FILTER
FILTER BOWL
ALUMINUM
FILTER ELEMENT
INLET
BYPASS INLET
OUTLET
RED
POPOUT
BUTTON
ACCESSORY
GEARBOX
BYPASS VALVE SEAT
IMPENDING BYPASS
INDICATOR ASSEMBLY
OIL FILTER BOWL
BYPASS
INDICATOR
BYPASS VALVE
83-641B

NOTES

4. Oil filter

   a. Filters engine oil down to 3 microns.

   b. New oil from the can is filtered down to only 8 microns, therefore oil samples are not required on T700 series engines.

   c. The oil filter consists of a filter element, filter bowl and impending bypass indicator, and a bypass valve and inlet screen.

      (1) Filter element

         (a) Element media is resistant to high temperatures.

         (b) Composed of organic and inorganic fibers.

         (c) Media is faced on both sides with stainless steel mesh.

         (d) Pleating of material adds surface area and rigidity.

         (e) A perforated steel tube in the bore adds rigidity and helps to maintain the circular shape of the element.

         (f) Filtration level is 100% of all particles 3-microns in size or larger.

      (2) Bowl and impending bypass filter indicator

         (a) Bowl houses filter element.

         (b) Bowl is mounted horizontally for easy access and servicing.

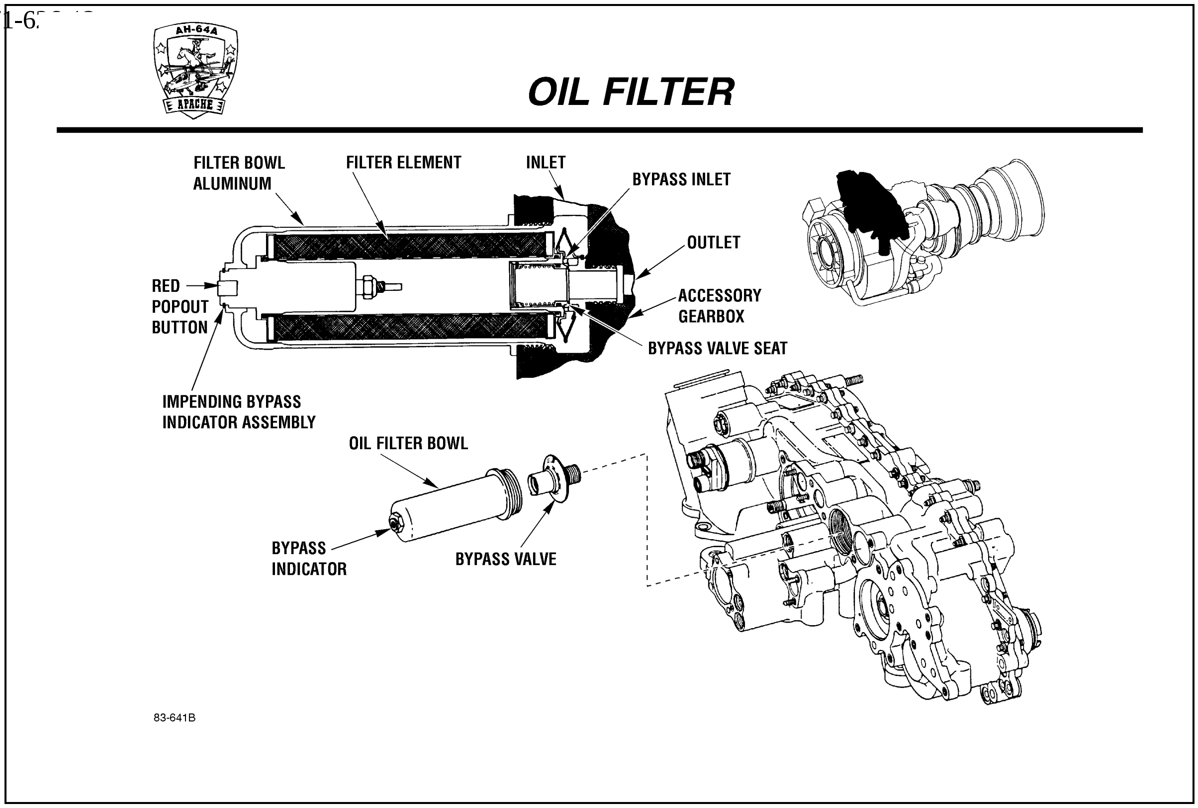
         (c) Bypass indicator is installed from the inside of the bowl and held in place with an external retaining ring.

         (d) Operation

            1) Extends red pop-out button to indicate a pressure differential of 44 to 60 PSI.

            2) The piston contains a magnet which attracts the bypass indicator and holds it seated against the spring.

            3) When the piston moves, the button is released and extends 3/16" to visually indicate an impending bypass condition.


AH-64A
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OIL FILTER BOWL
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INDICATOR
BYPASS VALVE
83-641B

NOTES

4) As the button is released, a small ball moves out of position to latch the button and prevents the button from being reset.

5) The internal piston assembly automatically resets on shutdown; however, the indicator remains latched out.

6) To reset the indicator, the bowl is held vertical so that the latch ball can roll out of the latch position. The button is then reset manually.

7) When the bowl is removed from the gearbox and the filter element is removed from the bowl, a spring-loaded sleeve around the indicator moves aft and pulls the piston assembly to a "tripped" position. The indicator trips if operation is attempted with no filter in the bowl.

8) Cold start false tripping is prevented by a bimetallic latch below 100 degrees F. (38 degrees C.)

(e) Filter bowl must be removed to reset indicator button.

(3) Bypass relief valve and inlet screen

(a) Bypass relief valve opens when pressure differential between inlet and outlet sides of filter element exceed 95 PSI.

(b) Located between the accessory case and the filter bowl.

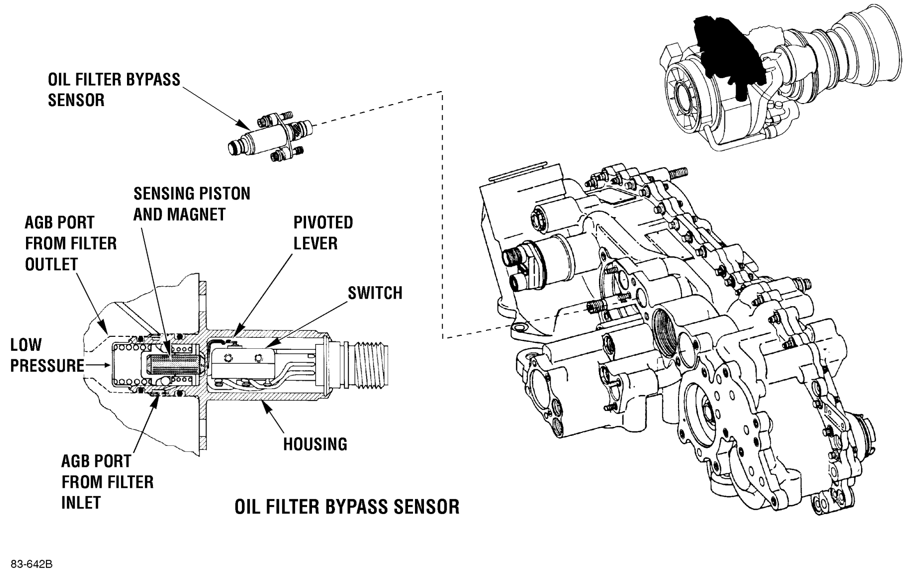
(c) A normally closed valve.

1) High differential oil pressure indicates a dirty filter element or the oil is too cold, causing the bypass valve to remain open.

2) The bypass valve closes when the oil temperature warms to 100E F (38E C).

(d) Inlet screen prevents foreign objects 3-microns or larger from entering the engine accessory case.

OIL FILTER BYPASS SENSOR



NOTES

5. Oil filter bypass sensor

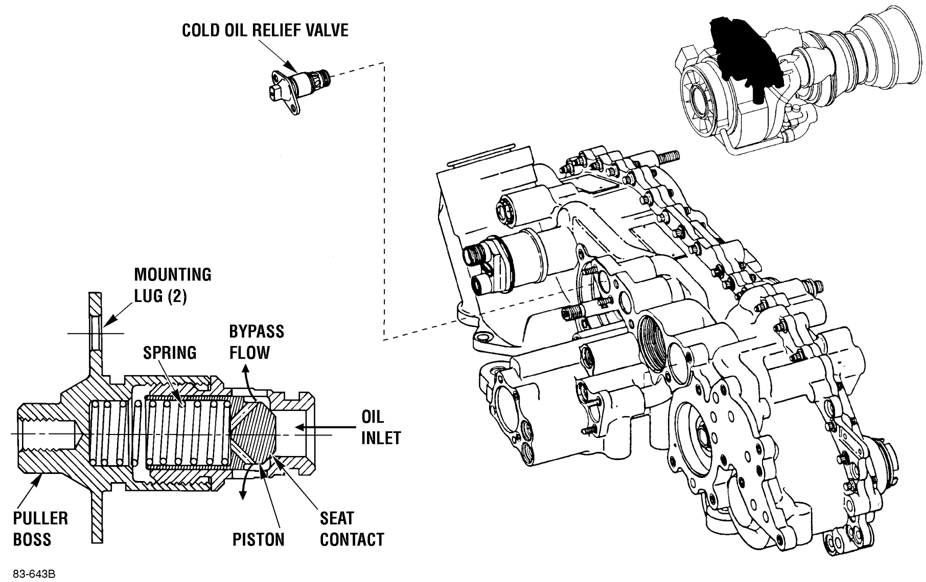
    a. Monitors differential oil pressure across the oil filter.

    b. Provides an electrical signal to the pilot OIL BYP ENG 1 or 2, and the CPG ENG 1 or 2 caution lights when the differential pressure between the oil filter inlet and outlet reaches 60 to 80 PSID increasing.

    c. The switch connects 28 VDC when tripped and reopens the circuit at 15 PSID.

    d. No latch is used in the sensor, resetting is automatic.

COLD OIL RELIEF VALVE



NOTES

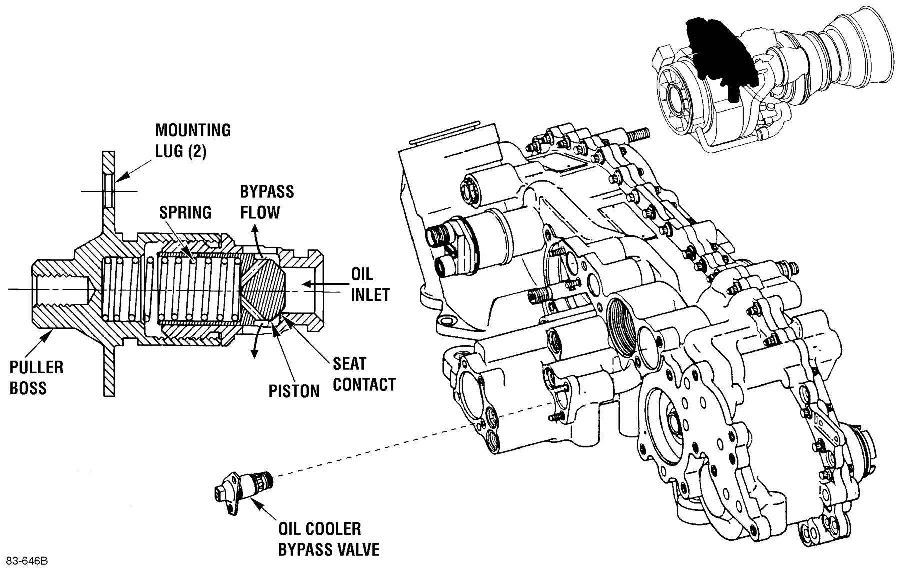
6. Cold oil relief valve

   a. Protects engine lubrication system from excessive pressure during initial starts.

   b. Mounted on the front of the engine accessory gearbox.

   c. A conventional poppet valve with a cracking pressure of 120 to 180 PSI.

OIL COOLER BYPASS VALVE



NOTES

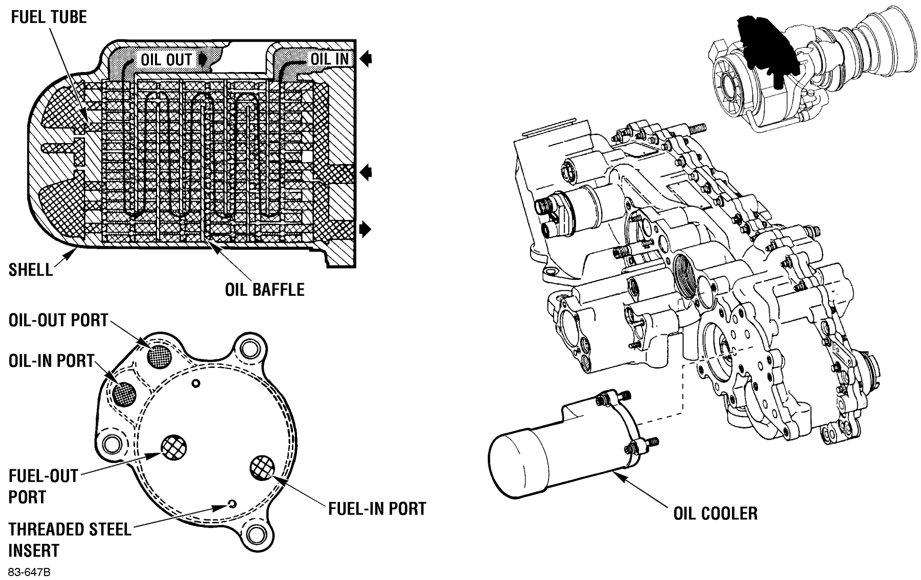
7. Oil cooler bypass valve

   a. Directs oil to the oil tank when the oil is cold or the oil cooler is clogged.

   b. A conventional poppet valve with a cracking pressure of 22 to 28 PSI.

   c. Although similar in function and appearance to the cold oil relief valve, the oil cooler bypass valve is not interchangeable and will not fit if an attempt is made to switch one for the other.

OIL COOLER



NOTES

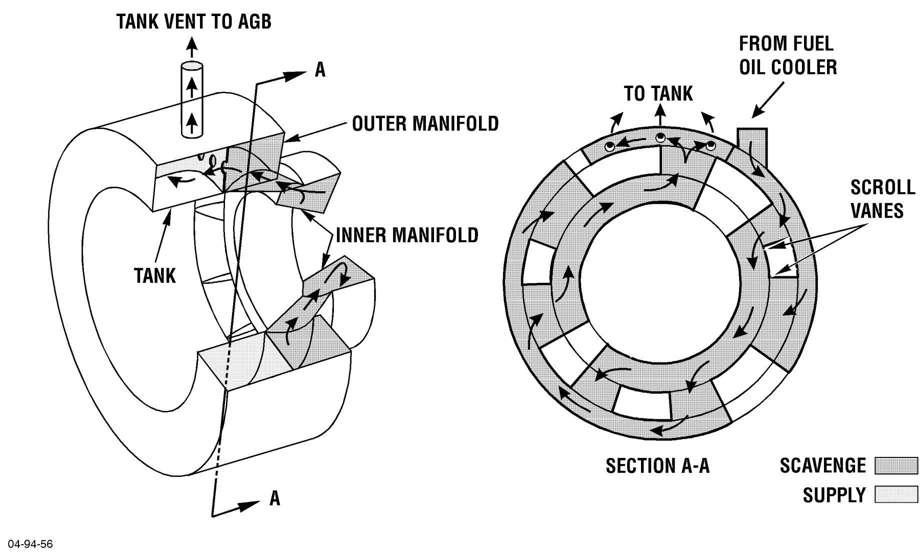
8. Oil cooler

   a. Transfers heat from the oil to the fuel.

   b. Mounts on the front of the accessory gearbox.

   c. The oil cooler is a tube in shell type heat exchanger.

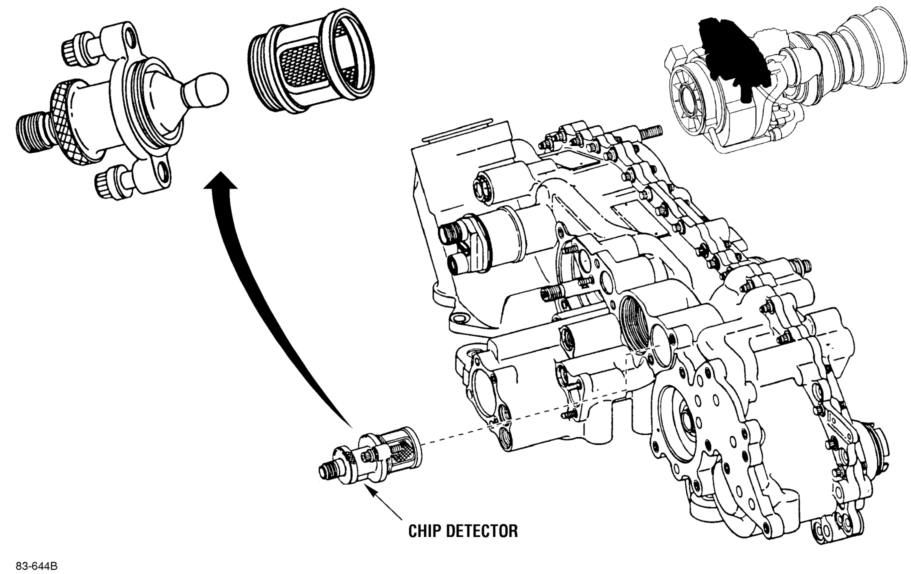
MAINFRAME OIL FLOW



NOTES

d. Oil is also cooled by convection. Heat is transferred to the air as oil from the AGB flows back to the reservoir through the scroll vanes of the mainframe.

CHIP DETECTOR



NOTES

9. Chip detector

   a. Illuminates CHIPS ENG 1 or 2 light in the pilot station and ENG 1 or 2 light in the CPG station when there are metal particles in the oil.

   b. Mounts on the front of the accessory gearbox and is part of the scavenge oil return system to the tank.

   c. Traps nonconductive particles in the screen.

   d. Consists of:

      (1) An outer shell with an internal magnet

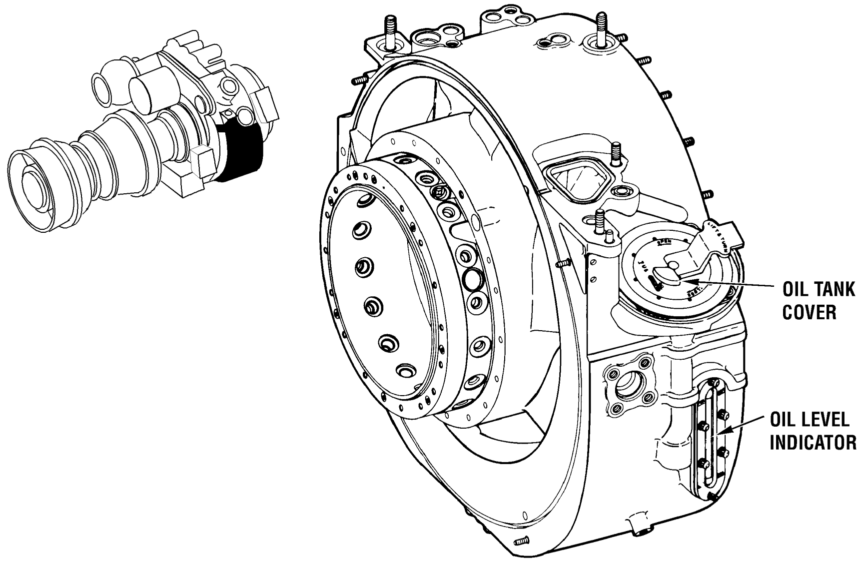
      (2) Electrical connector

      (3) Removable screen

   e. When particles bridge the gap between the magnet and outer shell, they complete a circuit causing the appropriate caution lights to illuminate.

   f. NO fuzz suppression capabilities.

OIL TANK



83-648

NOTES

10. Oil tank

  a. Integral component of the cold section module, main frame.

  b. 7.3 quart capacity

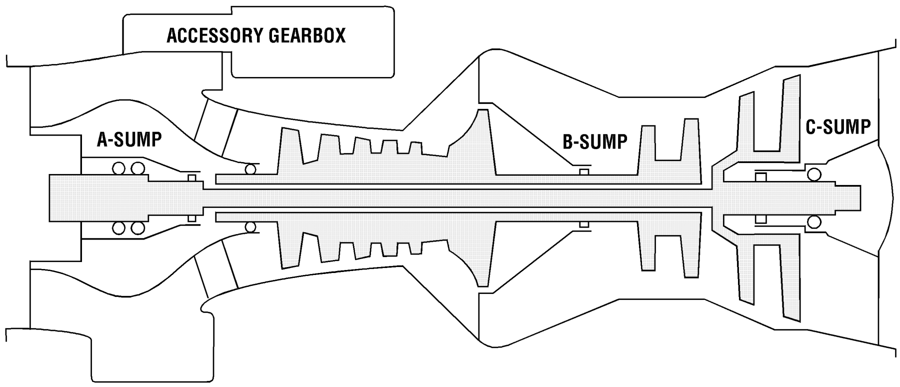
  c. Fill using the gravity fill port, located on the right side of the tank.

    (1) A visual fluid level indicator (sight gauge) is provided on each side of the tank.

    (2) A coarse screen at the bottom of tank prevents debris from going into lube supply inlet pump.

    (3) A drain plug is located at the bottom of the tank.

SUMPS ("A"-"B"-"C")



83-649

NOTES

11. Sumps

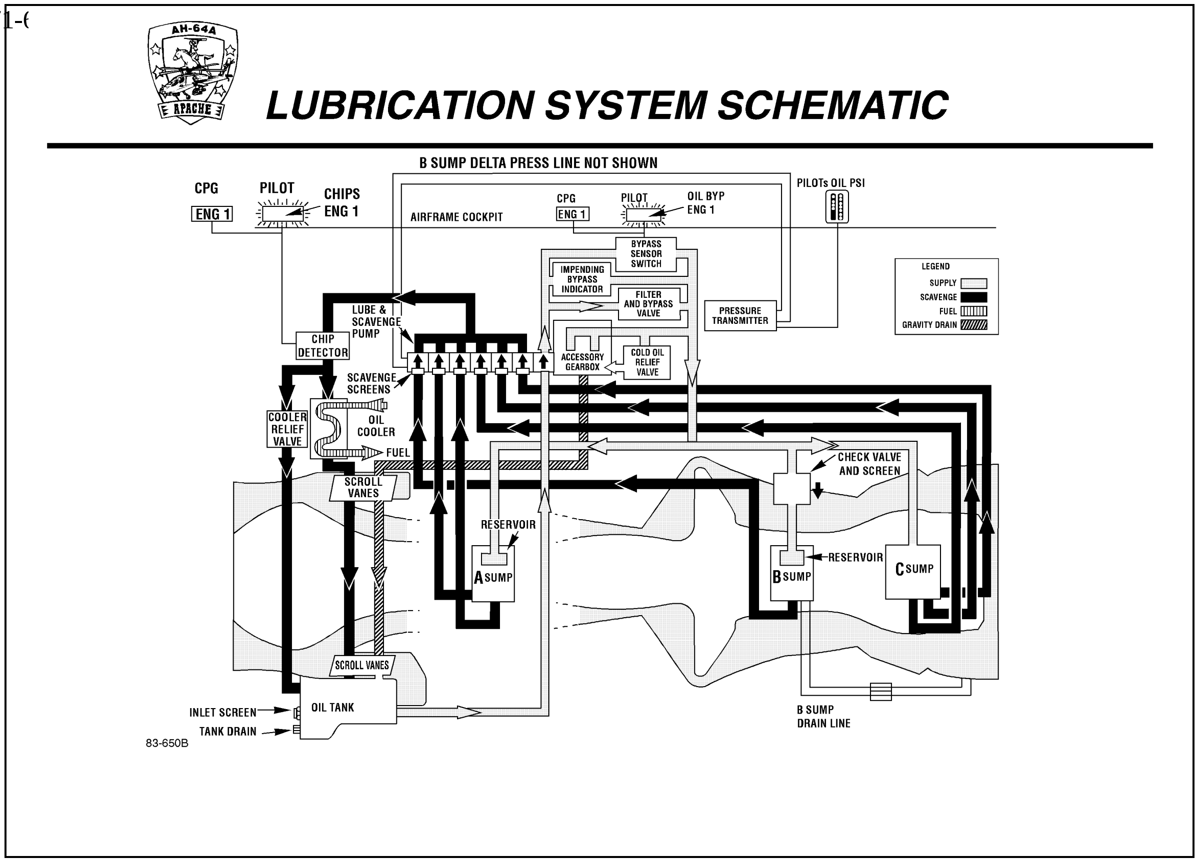
a. Sumps

(1) Provide a cavity for oil scavenging

(2) Houses a reservoir to store oil for emergency lubrication

(3) Houses main engine bearings

(4) The A and B sumps have provisions for emergency lubrication, but the C sump does not.


AH-64A
APACHE
LUBRICATION SYSTEM SCHEMATIC
B SUMP DELTA PRESS LINE NOT SHOWN
CPG
ENG 1
PILOT
CHIPS
ENG 1
AIRFRAME COCKPIT
CPG
ENG 1
PILOT
OIL BYP
ENG 1
PILOTs OIL PSI
BYPASS SENSOR SWITCH
IMPENDING BYPASS INDICATOR
FILTER AND BYPASS VALVE
PRESSURE TRANSMITTER
LEGEND
SUPPLY
SCAVENGE
FUEL
GRAVITY DRAIN
LUBE & SCAVENGE PUMP
CHIP DETECTOR
ACCESSORY GEARBOX
COLD OIL RELIEF VALVE
SCAVENGE SCREENS
COOLER RELIEF VALVE
OIL COOLER
FUEL
CHECK VALVE AND SCREEN
SCROLL VANES
RESERVOIR
A SUMP
B SUMP
RESERVOIR
C SUMP
SCROLL VANES
INLET SCREEN
OIL TANK
TANK DRAIN
83-650B
B SUMP DRAIN LINE

NOTES

H. Lubrication system operation

1. Normal operation

a. Oil is drawn from the tank to the oil and scavenge pump.

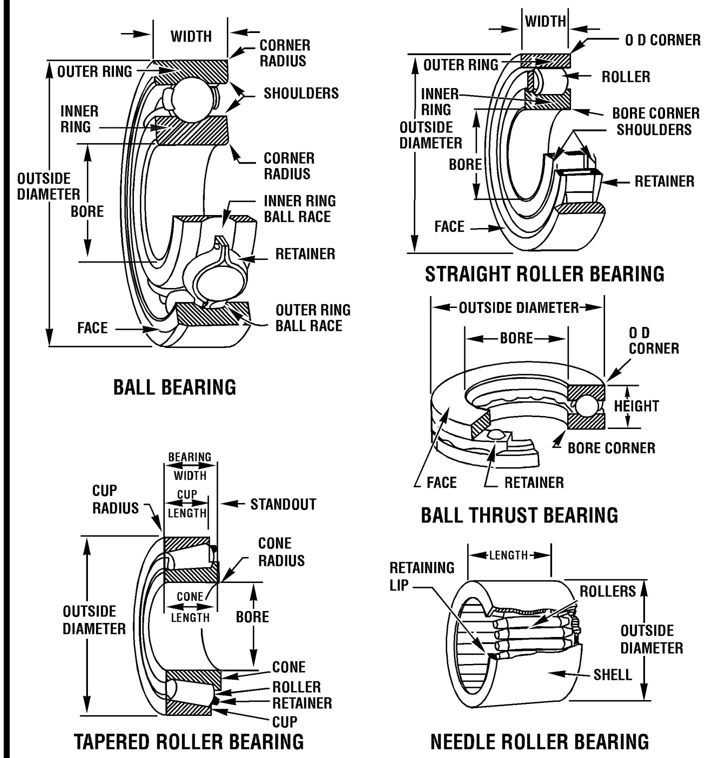
b. From the pump, pressurized oil flows through the oil filter and into passages in the accessory gearbox.

c. Inside the gearbox, the flow divides and flows to the A, B, and C sumps and to the gearbox.

d. Inside the sumps, jets spray oil on the bearings.

071-

BEARINGS



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NOTES

I. Bearing structure

1. General information

a. In the AH-64A, bearings are found throughout the power train system from the engines to the rotors. Failure of any one of these bearings would place the entire aircraft in jeopardy. It is crucial that they be properly serviced and maintained.

b. Bearings have the following functions. They:

(1) Support the load on a shaft. The load may be a wheel, pulley, gear; or it may be the turning shaft itself.

(2) Reduce friction created by turning. This is accomplished both by design and by lubrication and is one of the most important functions of a bearing.

(3) Reduce friction created by thrust. A specially designed bearing is required for this purpose.

(4) Hold a shaft in rigid alignment. A high speed rotating shaft has a tendency to "whip" unless adequately supported by bearings.

(5) Provide a place for adjustment.

c. Bearing loads

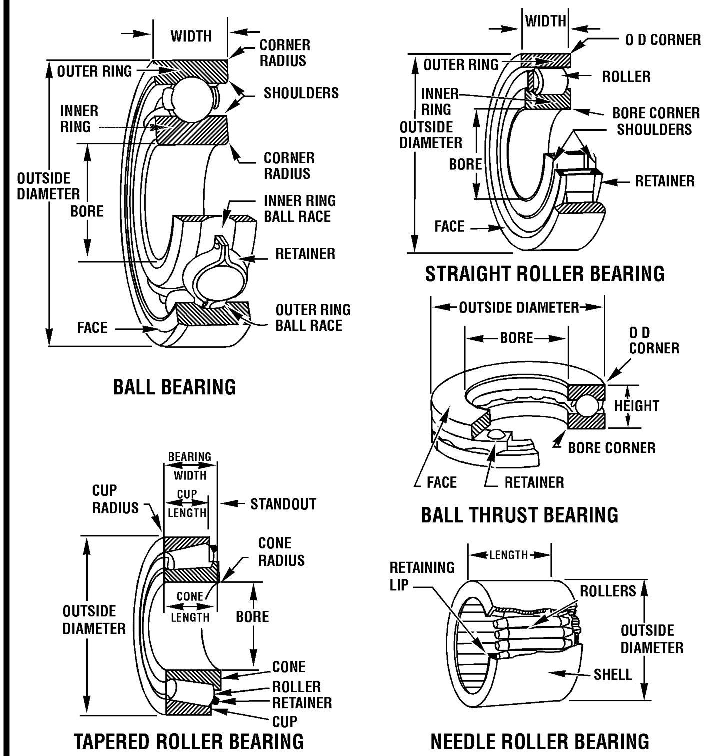
(1) The two types of bearing loads are:

(a) Radial. When a wheel turns, it produces centrifugal force. When this force is 90E from the shaft, it is known as radial loading.

(b) Axial/Thrust. When the force or load on the bearing is in a direction parallel to the shaft, it is known as axial/thrust loading.

(2) Many times a bearing is subjected to a combination of both radial and axial loads; for example, the crankshaft main bearings in a reciprocating aircraft engine. The throws on the crankshaft produce radial load while the pull of the propeller produces axial load.

BEARINGS



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NOTES

d. Bearings are classified into two broad categories:

(1) Friction - also commonly known as plain or babbitt type; it makes a sliding contact with the shaft.

(2) Rolling - contains rollers or balls; it makes a rolling contact with the shaft.

(3) Only rolling bearings are applicable to the T700-GE-701/701C engines. Therefore, only rolling bearings are discussed in this lesson.

e. Rolling bearings

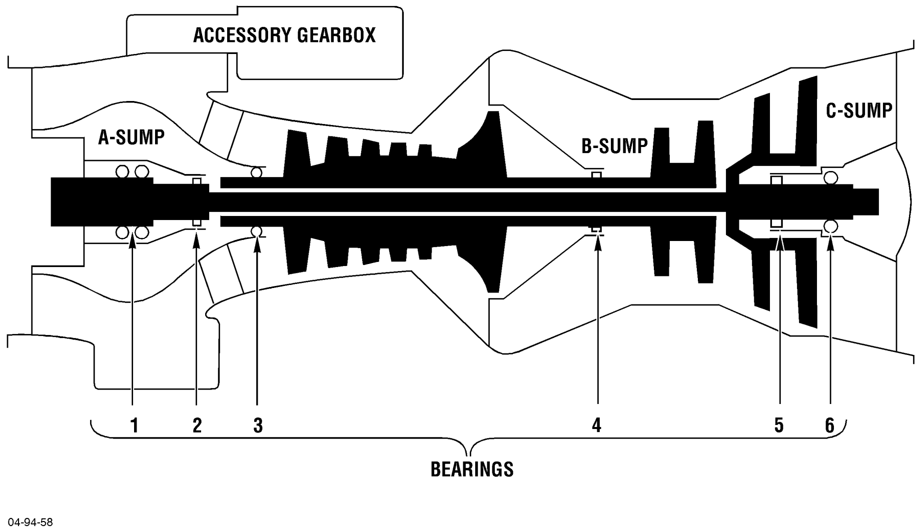
(1) Rolling bearings are classified into two types: ball and roller.

(a) Ball bearings. The ball bearing creates the least amount of friction of any common bearing because the ball itself is the best anti-friction rolling device known. The ball maintains point contact with the surface it rolls upon and reduces friction to a minimum. It is, therefore, best suited to high speed applications. Ball bearings can accept both radial and axial loads.

(b) Roller bearings. The roller bearing makes use of a cylindrical shaped roller between the friction surfaces. Since it is a cylinder, it makes line contact rather than point contact. It is therefore more suited to heavy loads because the weight is distributed over a larger contact area. Radial bearings can accept radial loads only.

f. Some bearings may be suited for thrust or axial loads while others are not. Bearing design (size and number of balls, depth and type of groove, width and type of races, construction of the separators) determines the load and speed for which the bearing can be used. Bearings made to take both radial and thrust loads are increased on one side of the outer race and are usually stamped "thrust."

MAIN BEARINGS



NOTES

2. Specific information

a. The engine shafts and rotors are supported by six main bearings located in three sumps.

(1) The number 1 and number 2 bearings support the output shaft.

(2) The number 3 bearing is located on the forward end of the compressor and together with the number 4 bearing, located between the compressor and turbine, support the gas generator rotor.

(3) The number 5 and number 6 bearings provide support for the power turbine rotor.

b. Bearing type and function:

Bearing number	Type	Function
Number 1	Ball (duplex) thrust (5-piece)	Absorb radial and axial loads - output shaft
Number 2	Roller (2-piece)	Absorb radial loads - output shaft
Number 3	Ball (4-piece) thrust	Absorb radial and axial loads - gas generator rotor
Number 4	Roller (2-piece)	Absorb radial loads - gas generator rotor
Number 5	Roller (2-piece)	Absorb radial loads - power turbine rotor
Number 6	Ball (4-piece)	Absorb radial and axial loads - power turbine rotor

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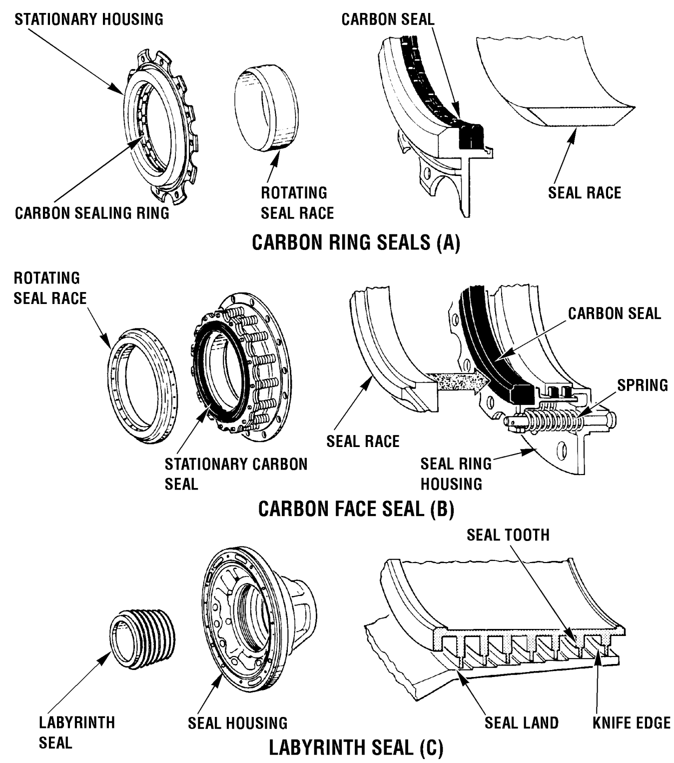
SEALS



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NOTES

J. Seals

1. The carbon seal is found where a positive control over airflow into the bearing sumps is required, or where full-contact-type seals hold back oil which might puddle before being scavenged. Labyrinth sealing is usually associated with oil system locations designed with higher vent subsystem pressures.

2. Labyrinth seals

   a. Labyrinth seals form a compartment in which the bearing is housed.

   b. Air from the gas path that is present outside of the bearing compartment bleeds inward across the grooves cut in the labyrinth seal. These groves form sealing rings in either a concentric path similar to a screw thread or are non-concentric with each ring in it's own plane.

   c. The "seal dams" formed by the rings allow for a metered amount of air from the engine gas path to flow inward. Pressure in this cavity is often maintained near atmospheric level.

   d. The oil mist created by the oil jet spraying on the rotating bearing is prevented from exiting the bearing compartment by the air entering across the labyrinth seal. The seal pressurizing air then leaves the bearing area by way of the scavenge oil system.

3. Carbon seals

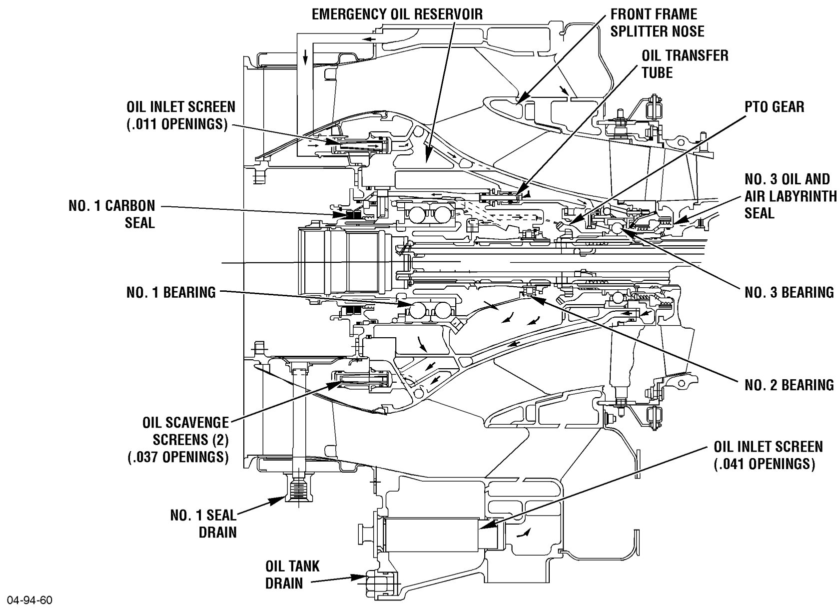
   a. Carbon seals are a blend of carbon and graphite, and are similar in function and location to labyrinth seals but not in design. The carbon seal rides on a highly polished surface, while the labyrinth seal maintains an air gap clearance.

   b. The carbon seal is usually spring-loaded and sometimes pressurized with air to create a uniform pressure of the carbon ring against it's mating surface, providing the oil sealing capability.

   c. The carbon-ring type seal rides on a rotating shaft. Another common design is the carbon-face type of seal.

   d. Carbon seals themselves are generally stationary, with their highly polished mating surface (seal race) attached to and turning with the shaft.

A-SUMP LUBRICATION SYSTEM



NOTES

K. Sumps

1. A-sump

a. Provides lubrication for # 1, # 2, and # 3 bearings, output shaft splines, and PTO gear mesh.

b. Return flow is gravity through two scavenge drains.

c. Contains an emergency oil reservoir.

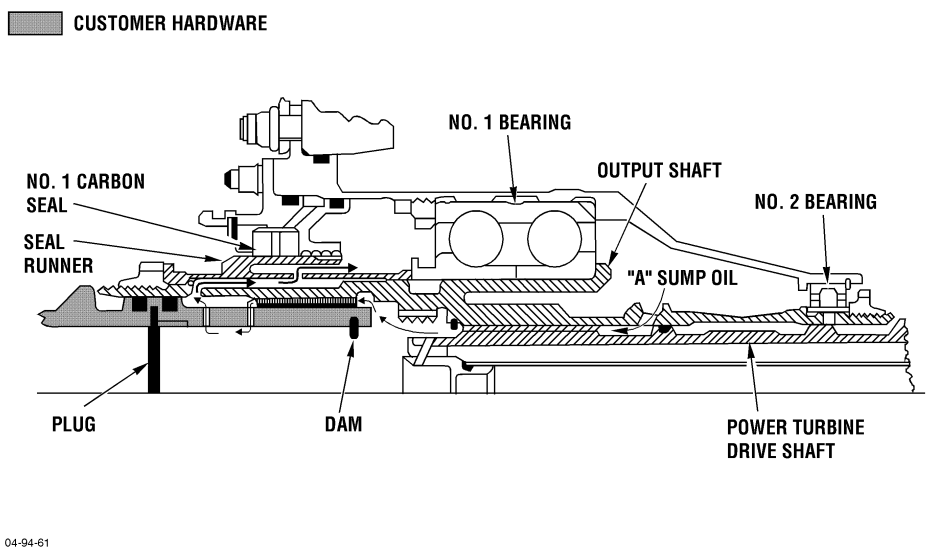
d. Operation

(1) Oil enters the A sump through the strut at the 3 o'clock position on the swirl frame.

(2) The A sump forward and aft scavenge lines are housed in the struts at the 10 and 2 o'clock positions.

(3) Oil is supplied to and scavenged from the A sump entirely through these internal lines.

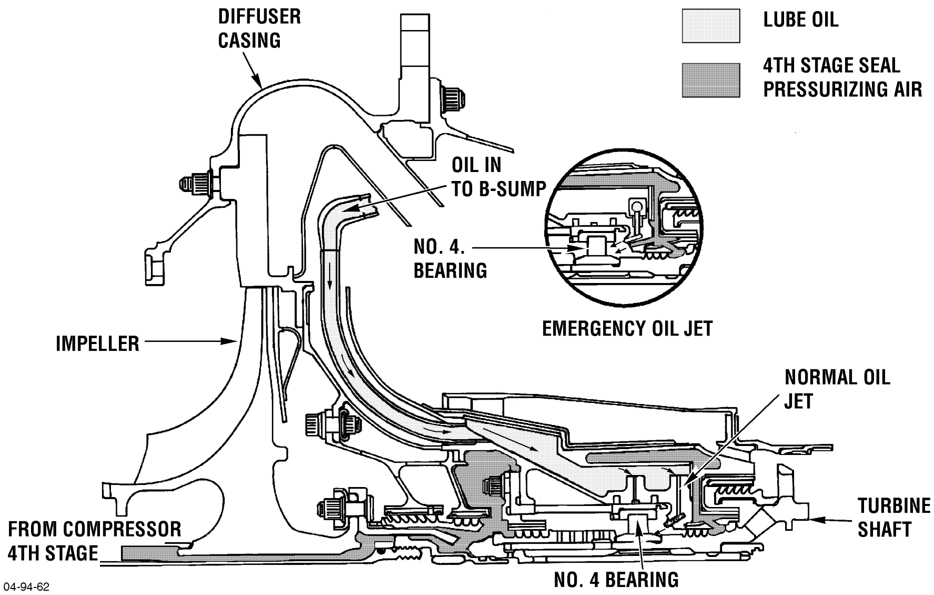
OUTPUT SHAFT SPLINE LUBRICATION



NOTES

e. Output shaft spline lubrication - eliminates the need for lubricating the spline with grease or CPC.

B-SUMP LUBRICATION SYSTEM



NOTES

2. B-sump

   a. Provides lubrication for the # 4 bearing.

   b. Oil is supplied to and scavenged from the B sump through an oil manifold assembly connected to the rear of the accessory gearbox.

   c. 4th stage bleed air pressurizes the B sump labyrinth seals.

   d. B sump check valve stops oil flow to sump upon shutdown to allow oil to drain from the sump.

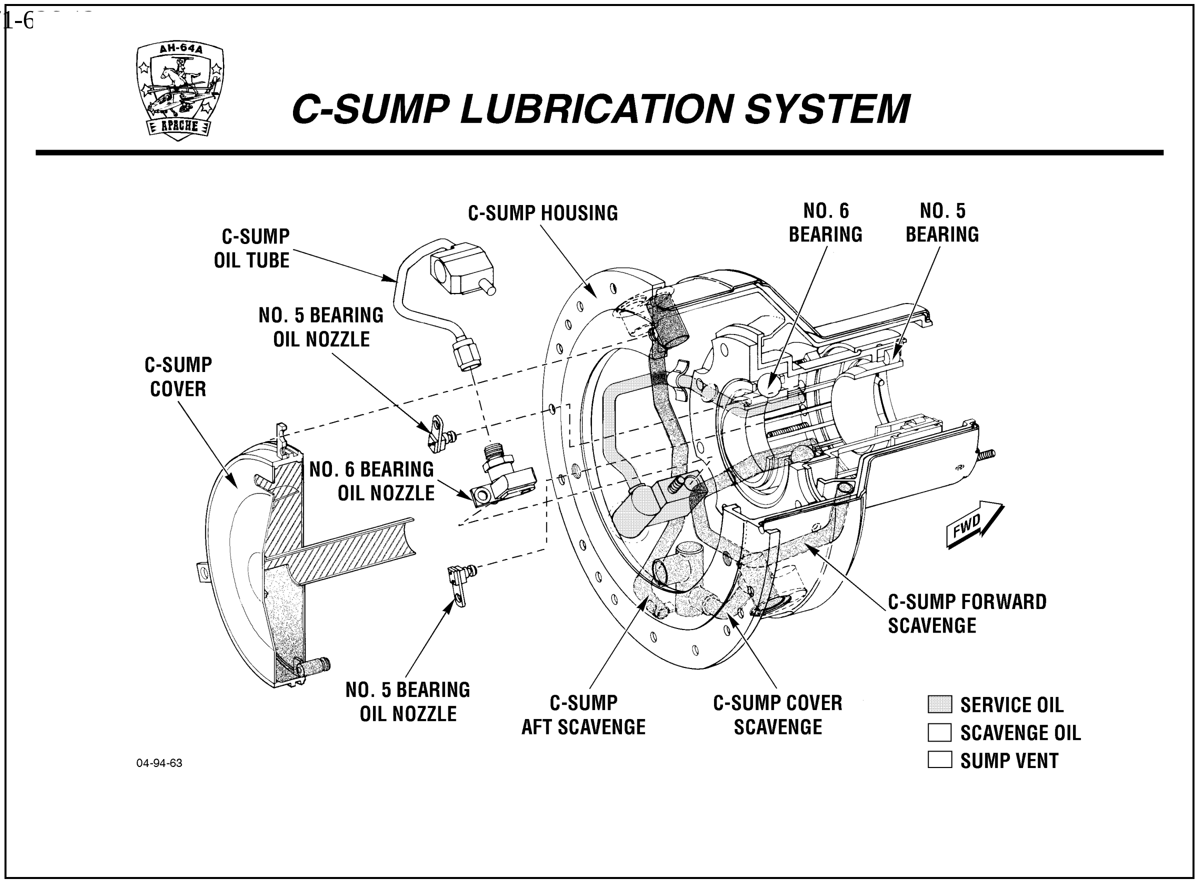
   e. Contains an emergency oil reservoir.

   f. Operation

      (1) Oil flow passes from the oil manifold assembly through the oil supply tubes and the B sump check valve.

      (2) Oil enters the B sump through a tube in the strut at the 1 o'clock position on the midframe.

      (3) Oil is scavenged from the B sump through a tube in the strut at the 9 o'clock position on the midframe.


AH-64A
APACHE
C-SUMP LUBRICATION SYSTEM
C-SUMP HOUSING
NO. 6
BEARING
NO. 5
BEARING
C-SUMP
OIL TUBE
NO. 5 BEARING
OIL NOZZLE
C-SUMP
COVER
NO. 6 BEARING
OIL NOZZLE
FWD
C-SUMP FORWARD
SCAVENGE
NO. 5 BEARING
OIL NOZZLE
C-SUMP
AFT SCAVENGE
C-SUMP COVER
SCAVENGE
SERVICE OIL
SCAVENGE OIL
SUMP VENT
04-94-63

NOTES

3. C-sump

   a. Provides lubrication for the # 5 and # 6 bearings.

   b. Oil is supplied to and scavenged from the C sump through an oil manifold assembly connected to the rear of the accessory gearbox.

   c. 4th stage bleed air pressurizes the C sump labyrinth seals.

   d. Operation

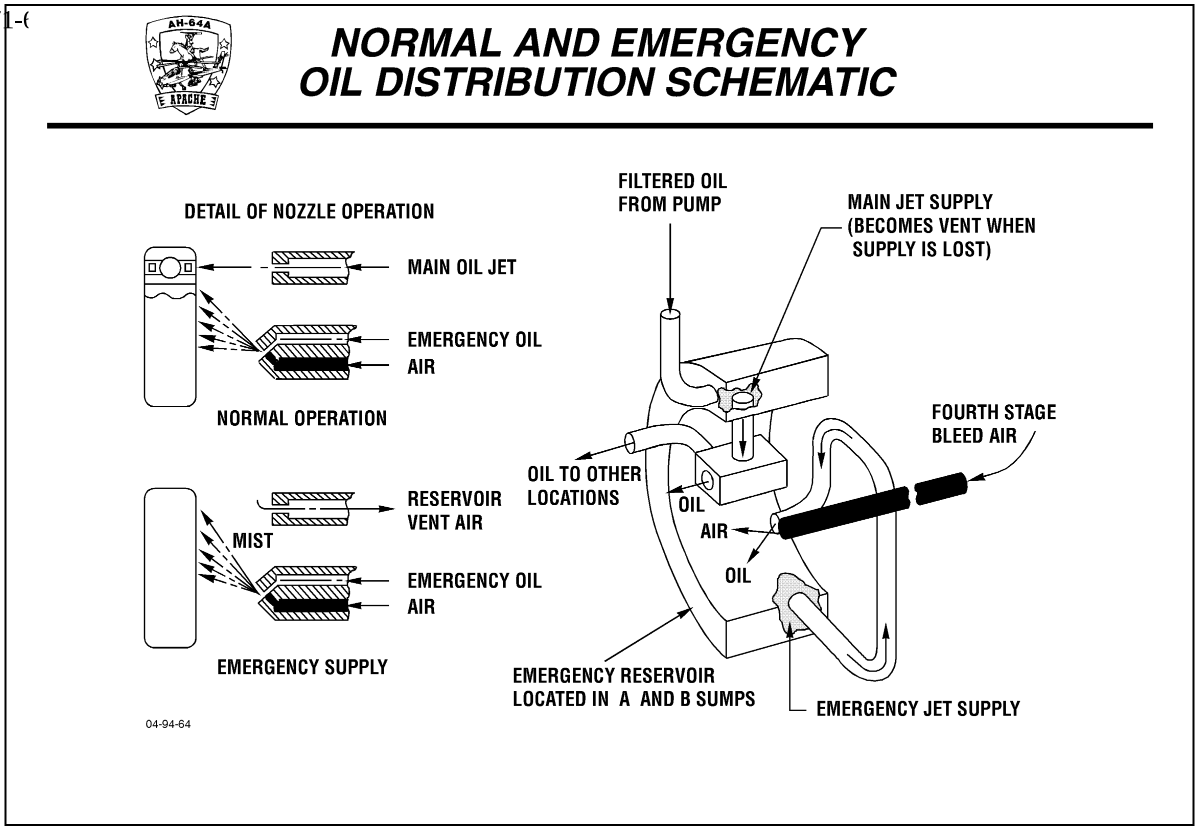
      (1) Oil flow passes from the oil manifold assembly through the C sump oil supply tube. This tube is located in the strut at the 7:30 o'clock position on the exhaust frame.

      (2) Oil is scavenged from the C sump through the C sump forward scavenge tube (2 o'clock position), aft scavenge tube (10 o'clock position), and through the seal pressure and scavenge tube assembly (4:30 o'clock position) which are located in the struts on the exhaust frame.

4. Scavenge oil

   a. Scavenge oil from the oil and scavenge pump flows through the electrical chip detector. Then it flows through the oil cooler and into the main frame.

   b. Scavenge oil enters a manifold at the top of the main frame. It then flows through the scroll vanes and into the oil tank.


NORMAL AND EMERGENCY
OIL DISTRIBUTION SCHEMATIC
DETAIL OF NOZZLE OPERATION
MAIN OIL JET
EMERGENCY OIL
AIR
NORMAL OPERATION
RESERVOIR
VENT AIR
MIST
EMERGENCY OIL
AIR
EMERGENCY SUPPLY
04-94-64
FILTERED OIL
FROM PUMP
MAIN JET SUPPLY
(BECOMES VENT WHEN
SUPPLY IS LOST)
FOURTH STAGE
BLEED AIR
OIL TO OTHER
LOCATIONS
OIL
AIR
OIL
EMERGENCY RESERVOIR
LOCATED IN A AND B SUMPS
EMERGENCY JET SUPPLY

NOTES

L. Emergency operation

1. If the oil system fails, the bearings are lubricated by an oil mist from the emergency oil system.

2. Small internal oil reservoirs in the A and B sumps are kept full during normal operation.

3. Oil from these reservoirs passes through the primary oil nozzles and the oil mist nozzle to lubricate the bearings.

4. When oil pressure is lost, the oil mist nozzles continue to supply oil from the reservoirs to the bearings in the A and B sumps.

    a. Oil feeds from emergency reservoir.

    b. 4th stage bleed air draws oil from the reservoir by creating a low pressure area at emergency oil jet tip.

    c. The main jet becomes a vent for emergency reservoir.

5. The emergency oil system is intended to maximize the time an engine can operate at reduced power conditions (30 seconds at 75% N_G) with a partial loss of oil or oil pressure.

FUELS

- FUEL REQUIREMENTS
- FUEL PROPERTIES
- FUEL GRADES

04-94-65

NOTES

A. Fuels

1. Fuel requirements - An engine fuel must be tailored to an engine and vice versa since there must be enough quantities of fuel available for the engine.

2. Fuel properties

a. Heat energy content

(1) The energy content or heating value of a fuel is expressed in heat units (British thermal units [BTUs]).

(2) A fuel satisfactory for aircraft engines must have a high heat energy content per unit weight. (To increase payload capacity.)

(3) Aviation fuels have relatively high heat contents.

(a) Heat energy content for aviation gasoline is about 18,700 BTUs per pound.

(b) Heat energy content for JP fuels is about 18,200 BTUs per pound.

(c) Alcohols have a maximum heat energy content of about 12,000 BTUs per pound.

b. Volatility

(1) A volatile liquid is one capable of readily changing from a liquid to a vapor when heated or when contacting a gas into which it can evaporate.

(2) JP fuels have a rather low volatility while aviation gasoline is highly volatile.

c. Stability

d. Purity

e. Flash point. The flash point is the lowest temperature at which fuel vaporizes enough to form a combustible mixture of fuel vapor and air above the fuel.

f. Fire point. The fire point is the temperature that must be reached before enough vapors rise to produce a continuous flame above the liquid fuel.

FUELS

- FUEL REQUIREMENTS
- FUEL PROPERTIES
- FUEL GRADES

04-94-65

NOTES

g. Reid vapor pressure

(1) Reid vapor pressure is the approximate vapor pressure exerted by a fuel when heated to 100EF.

(2) This is important because it is used to determine when a fuel creates a vapor lock.

h. Specific gravity

(1) Specific gravity is the ratio of the density (weight) of a substance (fuel) compared to that of an equal amount of water at 60EF.

(2) Specific gravity is expressed in terms of degrees API.

(3) Pure water has a specific gravity of 10.

(a) Liquids heavier than water have a number less than 10.

(b) Liquids lighter than water have a number greater than 10.

3. Grades. The fuels authorized for army aircraft gas turbine engines are JP-4, JP-5, and JP-8. The letters "JP" stand for jet propulsion; the numbers 4, 5, and 8 indicate fuel grades.

a. JP-4 is a fuel consisting of approximately 65% gasoline and 35% light petroleum distillate, with rigidly specified properties.

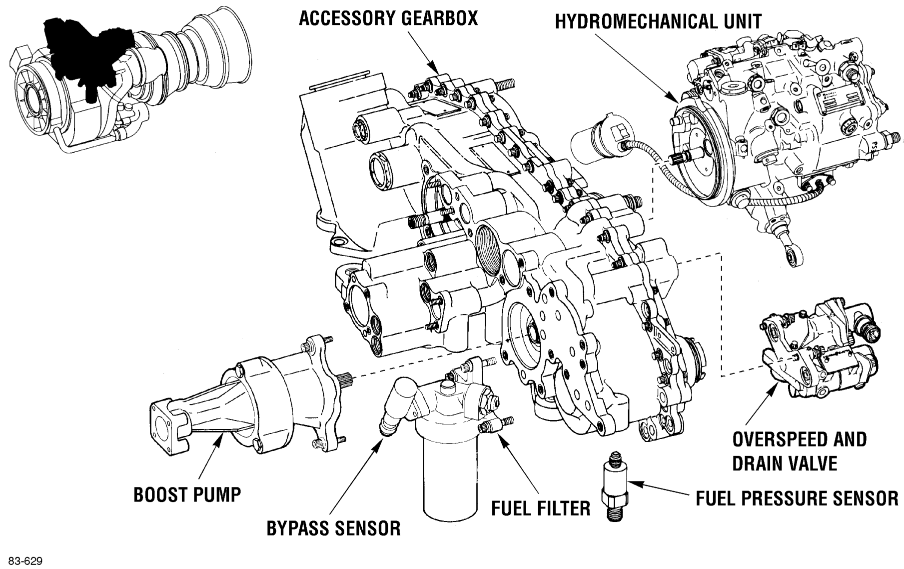
b. JP-5 is a specially refined kerosene having a minimum flash point of 140EF and a freezing point of -51EF.

c. JP-8 is a specially refined kerosene with a minimum flash point of 110EF and a freezing point of -54EF.

d. Jet B is a JP-4 type fuel.

e. Jet A and A-1 are kerosene type fuels differing primarily in their freezing points.

ENGINE FUEL SYSTEM COMPONENTS



NOTES

B. T700-GE-701/701C fuel system

1. The fuel system operates with the engine electrical system to provide proper fuel flow to the engine during starting, acceleration, deceleration, and steady-state operation.

2. The system maintains constant power turbine rotor speed (N_P) and provides load-sharing between engines.

3. The primary requirements of the fuel system are:

   a. To accurately control and stabilize engine speed for all steady-state operations, and to provide transient control for rapid power changes. The fuel system pumps, filters, and meters fuel in response to:

      (1) Power available spindle (PAS) position.

      (2) Load demand spindle (LDS) position.

      (3) Sensed engine variables.

      (4) Torque motor input from the electrical control unit (ECU) or digital electronic control unit (DECU).

   b. To position the compressor variable stator vanes throughout the engine operating range to achieve the required compressor performance with respect to airflow and stall margin.

   c. To provide a schedule for starting bleed.

   d. To provide automatic start schedules from sea level to 20,000 feet.

   e. To protect the engine against destructive N_G and N_P overspeeds.

4. The components of the fuel system include:

   a. Fuel boost pump

   b. Fuel pressure sensor

   c. Fuel filter

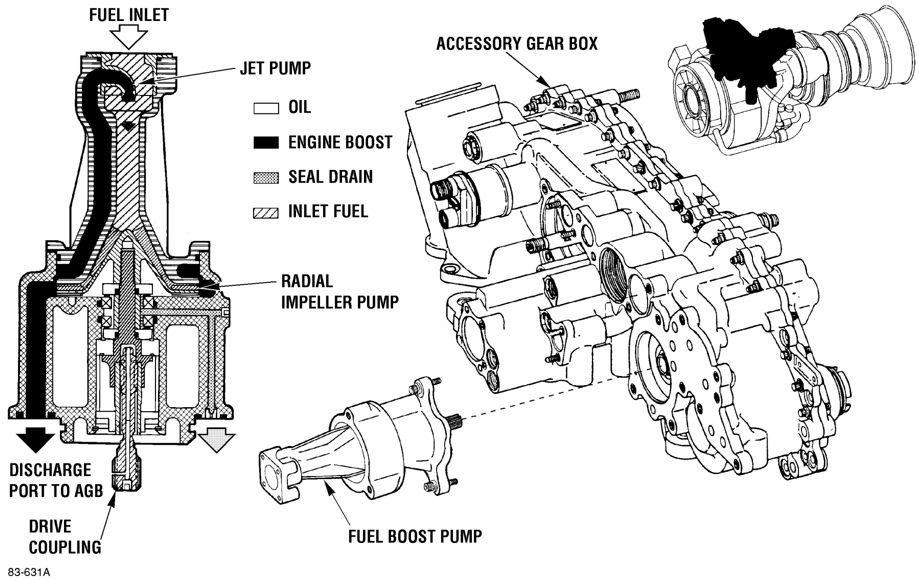
   d. Hydromechanical unit (HMU)

   e. Overspeed drain valve (ODV)

   f. Main fuel manifold

   g. Fuel injectors

FUEL BOOST PUMP



NOTES

C. Fuel system component characteristics

1. Fuel boost pump

a. Sucks fuel to the engine instead of pushing it from the tank.

b. Mounted on the front of the engine accessory gearbox.

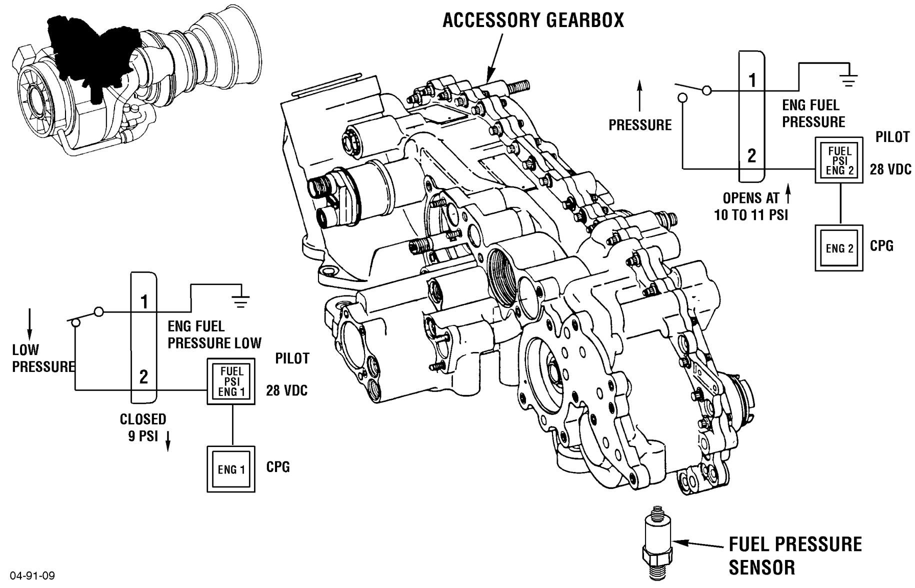
c. Increases fuel pressure

(1) 20 PSI at idle

(2) 45 - 90 PSI at 99% N_G

d. Engine driven, non-self-priming, pressure type, impeller pump.

FUEL PRESSURE SWITCH



NOTES

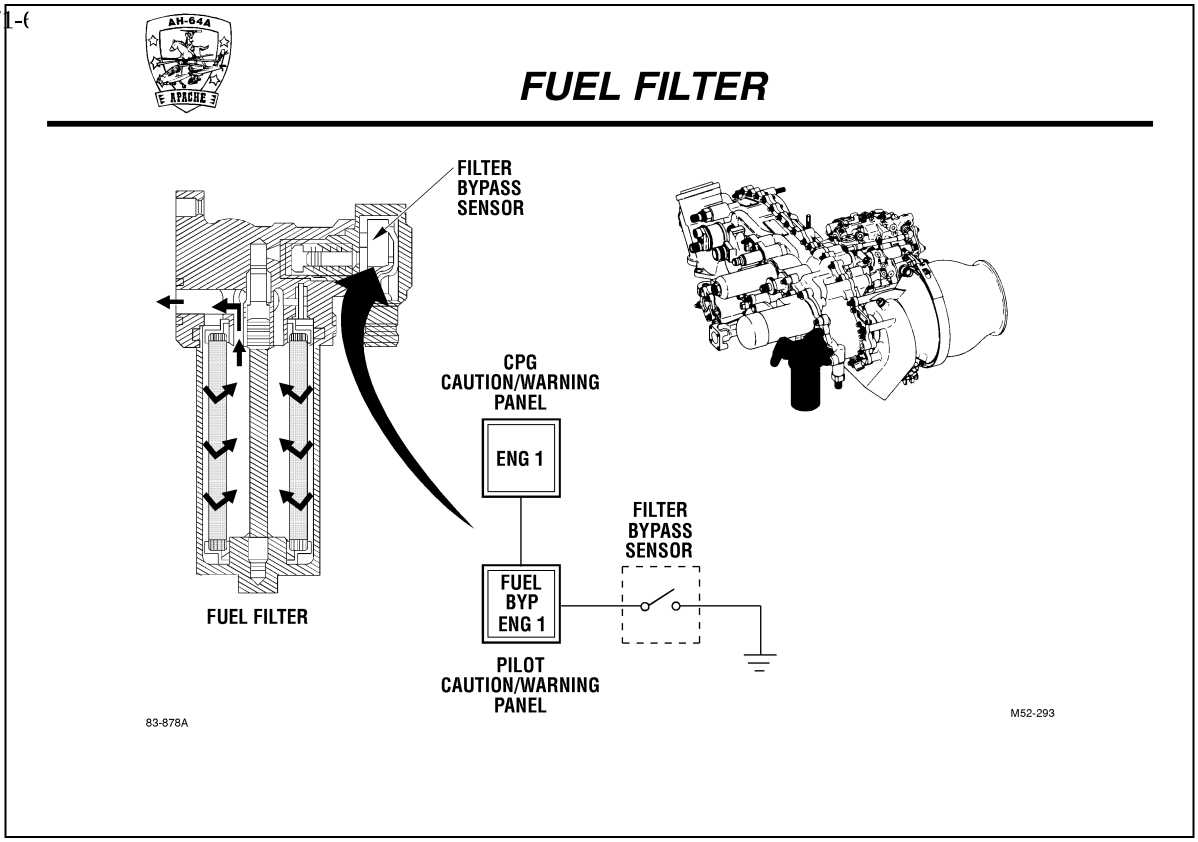
2. Fuel pressure switch

   a. Monitors fuel pressure from fuel boost pump to HMU.

   b. The fuel pressure sensor is located on the left side of the engine AGB.

   c. Illuminates pilot FUEL PSI ENG 1 or 2 and CPG ENG 1 or 2 caution light at 8.5 "0.5 PSI decreasing.

   d. Extinguishes lights at 10.5 "0.5 PSI increasing.


AH-64A
APACHE
FUEL FILTER
FILTER
BYPASS
SENSOR
CPG
CAUTION/WARNING
PANEL
ENG 1
FILTER
BYPASS
SENSOR
FUEL
BYP
ENG 1
FUEL FILTER
PILOT
CAUTION/WARNING
PANEL
83-878A
M52-293

NOTES

3. Fuel filter

a. The main parts of the fuel filter include:

(1) Disposable 30 micron filter

(2) Impending bypass indicator

(3) Bypass relief valve

(4) Filter bypass sensor

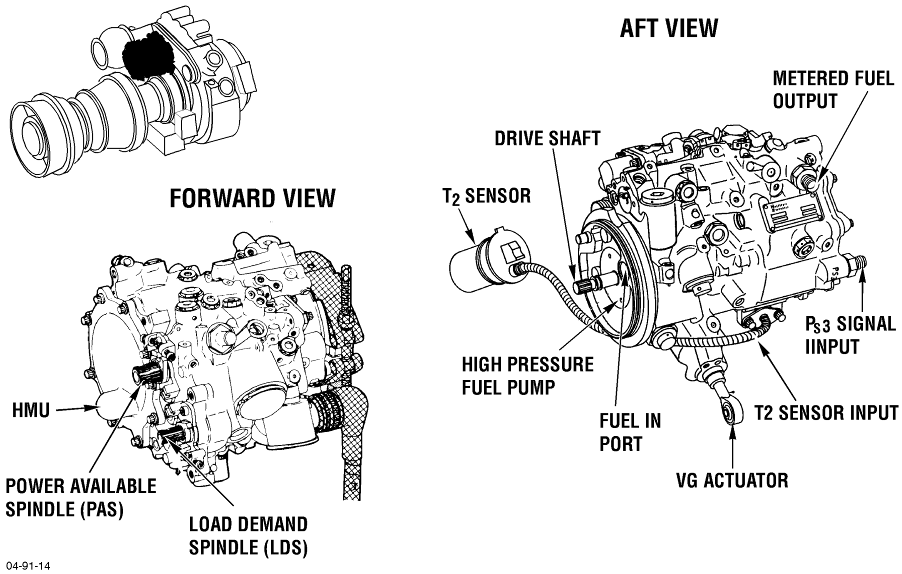
b. Impending bypass filter indicator button extends to indicate a pressure differential of 9 "1 PSID.

c. The bowl must be removed to reset the bypass button.

d. The bypass relief valve allows fuel to bypass fuel filter when differential pressure reaches 18 to 22 PSID.

e. The fuel bypass sensor provides an electrical signal to the pilot FUEL BYP ENG 1 or 2, and CPG ENG 1 or 2 light when the differential pressure reaches 18 to 22 PSID.

HYDROMECHANICAL UNIT (HMU)



NOTES

4. Hydromechanical unit (HMU)

NOTE

The HMU is designed to be adjusted at depot only. Adjustments to the HMU are safety wired to prevent adjustment at AVUM and AVIM.

a. The HMU schedules fuel for combustion. To accomplish this it:

(1) Provides high pressure fuel pumping, metering, flow computation, pressurization, and shutoff.

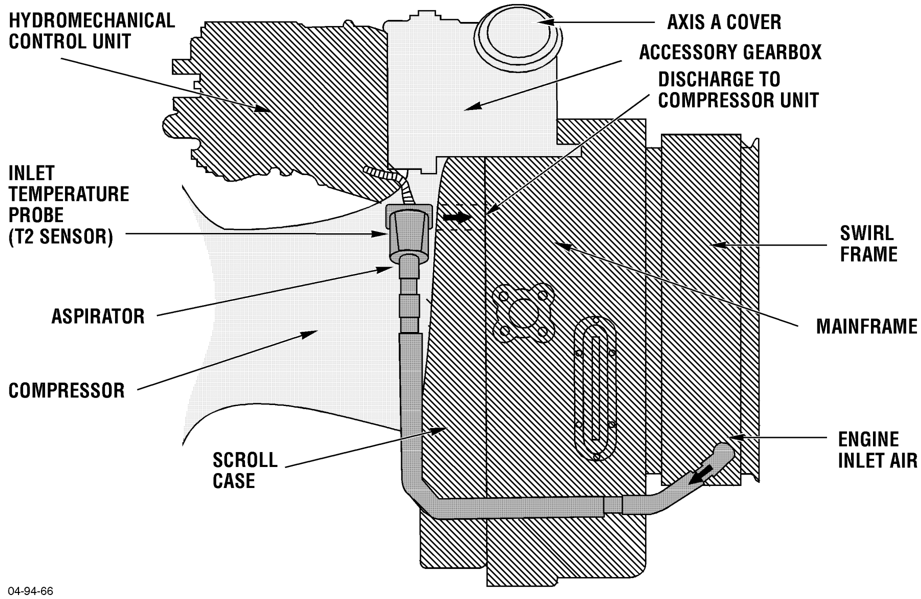
(2) Provides gas generator speed control, compressor variable inlet guide vane actuation, and anti-icing and start bleed valve actuation.

b. Housed within the HMU is the main fuel pump that increases fuel pressure received from the engine driven boost pump. **(832 PSI maximum).**

c. The HMU responds to the following inputs.

(1) N_G speed

T2 SENSOR AIRFLOW

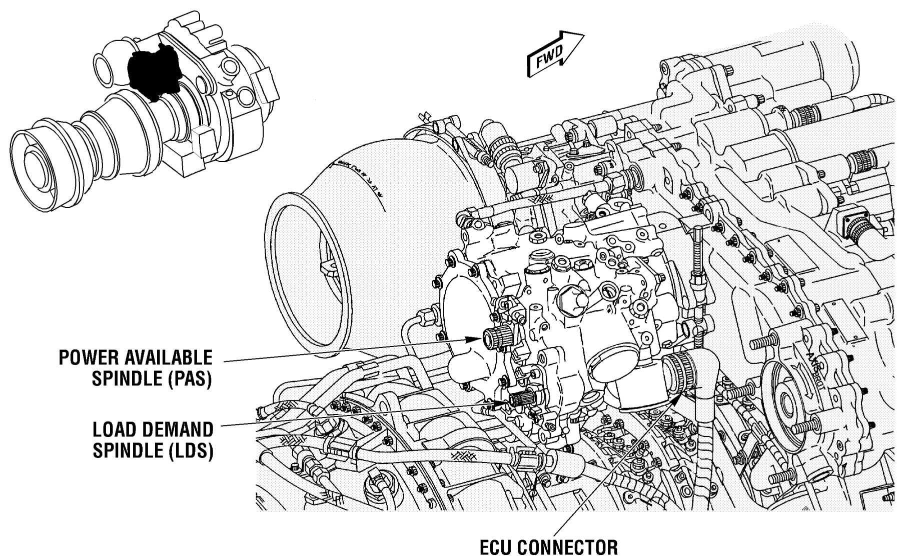


NOTES

(2) T2 sensor - provides the HMU with a signal of air temperature at the engine inlet.

(3) P3 air - P3 air is tapped at the midframe and provides the HMU with air pressure at the combustion chamber. This allows the HMU to schedule fuel and move the V_G actuator as required.

HYDROMECHANICAL UNIT (HMU) AFT VIEW



83-636A

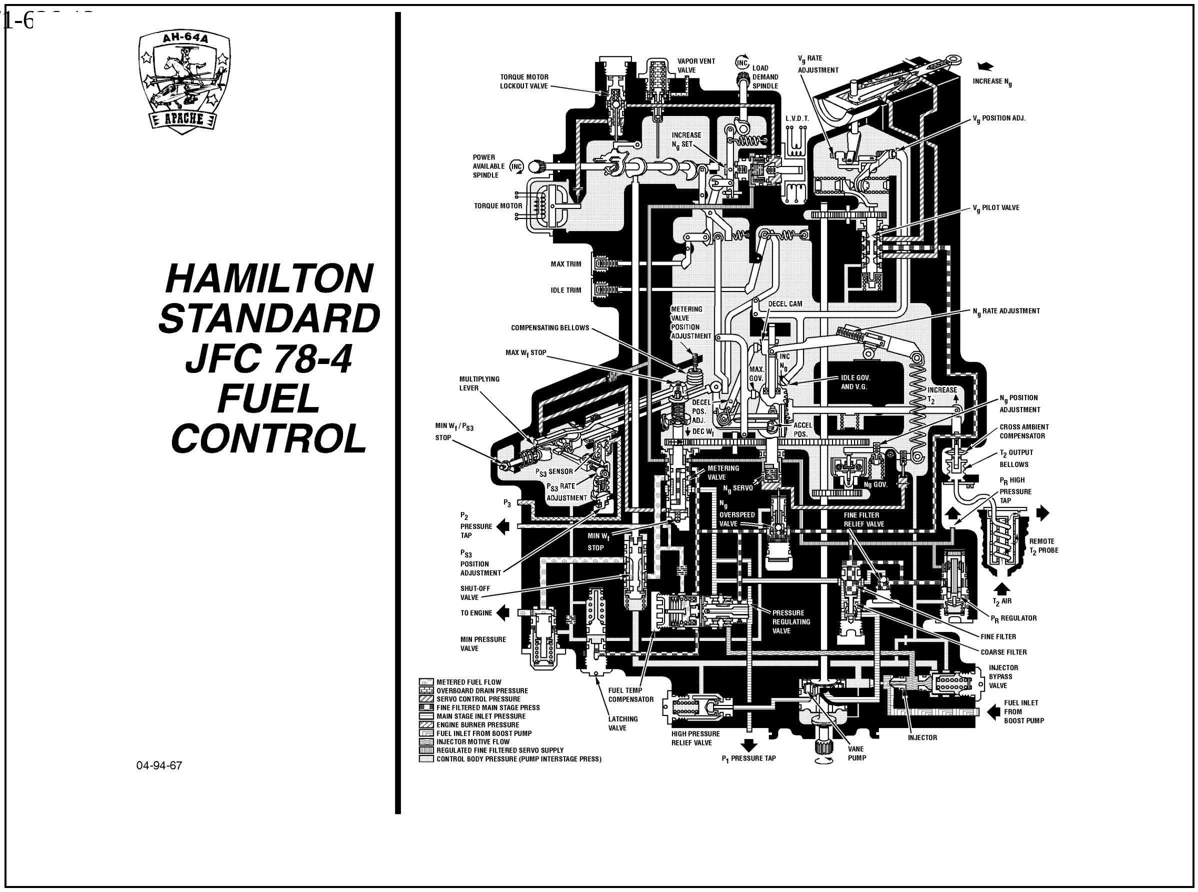
NOTES

(4) Power available spindle - provides input from the power lever for pilot control of the engine.

(5) Load demand spindle - provides input from the collective stick for different load demands.

(6) ECU/DECU - The torque motor receives inputs from the ECU/DECU through the yellow harness to trim N_G speed. Trimming the N_G speed controls N_P speed, provides torque load sharing, and provides TGT limiting.

(7) Proper installation of the HMU can be verified by looking through the mounting flange inspection hole for HMU to mount pad contact.


AH-64A
APACHE
HAMILTON STANDARD JFC 78-4 FUEL CONTROL
TORQUE MOTOR LOCKOUT VALVE
VAPOR VENT VALVE
INC
LOAD DEMAND SPINDLE
V_g RATE ADJUSTMENT
INCREASE N_g
V_g POSITION ADJ.
L.V.D.T.
INCREASE N_g SET
POWER AVAILABLE SPINDLE
TORQUE MOTOR
V_g PILOT VALVE
MAX TRIM
IDLE TRIM
METERING VALVE POSITION ADJUSTMENT
DECEL CAM
N_g RATE ADJUSTMENT
COMPENSATING BELLOWS
MAX W_f STOP
INC N_g
MAX. GOV.
IDLE GOV. AND V.G.
MULTIPLYING LEVER
INCREASE T_2
N_g POSITION ADJUSTMENT
DECEL POS. ADJ.
DEC W_f
ACCEL POS.
MIN W_f / P_{S3} STOP
CROSS AMBIENT COMPENSATOR
T_2 OUTPUT BELLOWS
P_{S3} SENSOR
P_{S3} RATE ADJUSTMENT
METERING VALVE
N_g SERVO
Ng GOV.
P_R HIGH PRESSURE TAP
P_3
P_2 PRESSURE TAP
N_g OVERSPEED VALVE
FINE FILTER RELIEF VALVE
MIN W_f STOP
REMOTE T_2 PROBE
P_{S3} POSITION ADJUSTMENT
T_2 AIR
SHUT-OFF VALVE
PRESSURE REGULATING VALVE
P_R REGULATOR
TO ENGINE
FINE FILTER
MIN PRESSURE VALVE
COARSE FILTER
INJECTOR BYPASS VALVE
METERED FUEL FLOW
OVERBOARD DRAIN PRESSURE
SERVO CONTROL PRESSURE
FINE FILTERED MAIN STAGE PRESS
MAIN STAGE INLET PRESSURE
ENGINE BURNER PRESSURE
FUEL INLET FROM BOOST PUMP
INJECTOR MOTIVE FLOW
REGULATED FINE FILTERED SERVO SUPPLY
CONTROL BODY PRESSURE (PUMP INTERSTAGE PRESS)
FUEL TEMP COMPENSATOR
LATCHING VALVE
HIGH PRESSURE RELIEF VALVE
P_1 PRESSURE TAP
VANE PUMP
INJECTOR
FUEL INLET FROM BOOST PUMP
04-94-67

NOTES

d. The torque motor lockout valve hydraulically disables the ECU from trimming fuel.

e. The LVDT sends the signal back to the ECU when trimming is accomplished.

f. The N_P servo is positioned by inputs from the PAS, LDS, and the Torque motor.

g. Vapor venting (engine priming)

(1) When the power levers are fully advanced, a cam on the power available spindle opens the vapor vent valve in the HMU.

(2) Fuel is ported from the HMU to the mount pad face on the accessory gearbox.

(3) Fuel is then routed within the accessory gearbox to a drain on the right side of the gearbox that is connected to a common drain port on the bottom of the engine nacelle and is dumped overboard.

h. N_G overspeed protection

(1) The N_G governor (internal to the HMU) consists of a set of flyweights similar to a prop governor.

(2) As N_G increases, the flyweights are "thrown out" by centrifugal force.

(3) This causes movement, through linkage and the 3D cam, of the N_G servo.

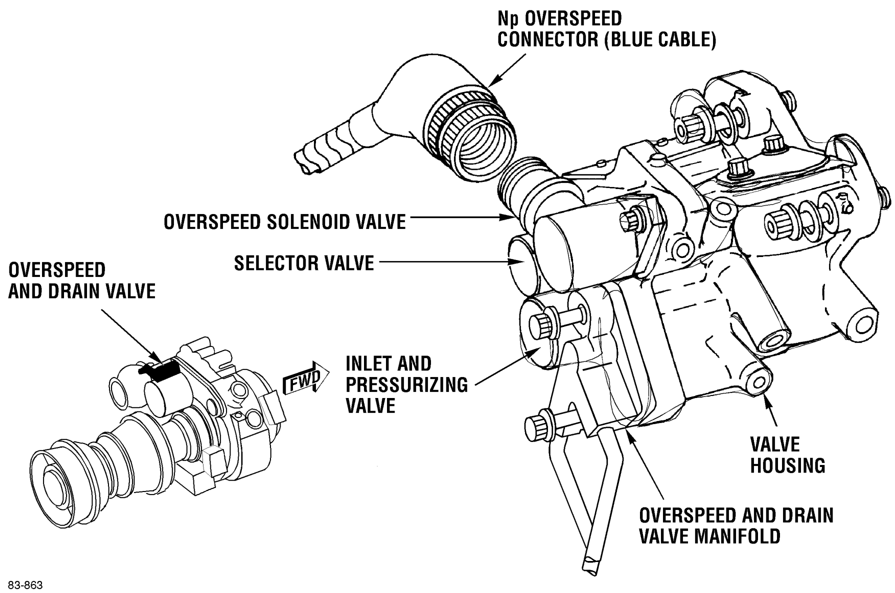
(4) If the N_G servo reaches a position corresponding to an N_G overspeed (110 "2% N_G) it contacts and actuates a spring loaded ball valve (N_G overspeed valve) which ports PF pressure (fine filtered main stage pressure) to case pressure (control body pressure).

(5) This allows a higher pressure fuel circuit to be ported to the spring side of the minimum pressure valve, causing it to close and shut off all fuel flow to the engine.

(6) Actuation of the N_G overspeed valve opens the latching valve and ports PF high pressure fuel directly from the servo filter thus holding the minimum pressure valve closed until PF pressure decays to case pressure.

(7) A spring force of 10 pounds (minimum) then closes the latching valve as N_G drops to zero.

OVERSPEED AND DRAIN VALVE



NOTES

5. Overspeed drain valve (ODV)

   a. The ODV has three functions.

      (1) It sends fuel through the main fuel manifold to the fuel injectors for starting, acceleration, and engine operation.

      (2) It purges the fuel injectors of fuel when the engine is shutdown. It does this by allowing compressor discharge air to flow through the injectors.

      (3) It controls N_P overspeeds by shutting off engine fuel flow while the overspeed is present.

   b. The ODV is located on the rear of the engine accessory gearbox.

   c. The ODV incorporates three valves.

      (1) Inlet and pressurizing valve - Allows fuel flow to pass to the selector valve. Opened by pressurized fuel from the HMU. When pressurized fuel is not present, the valve closes causing fuel to drain overboard.

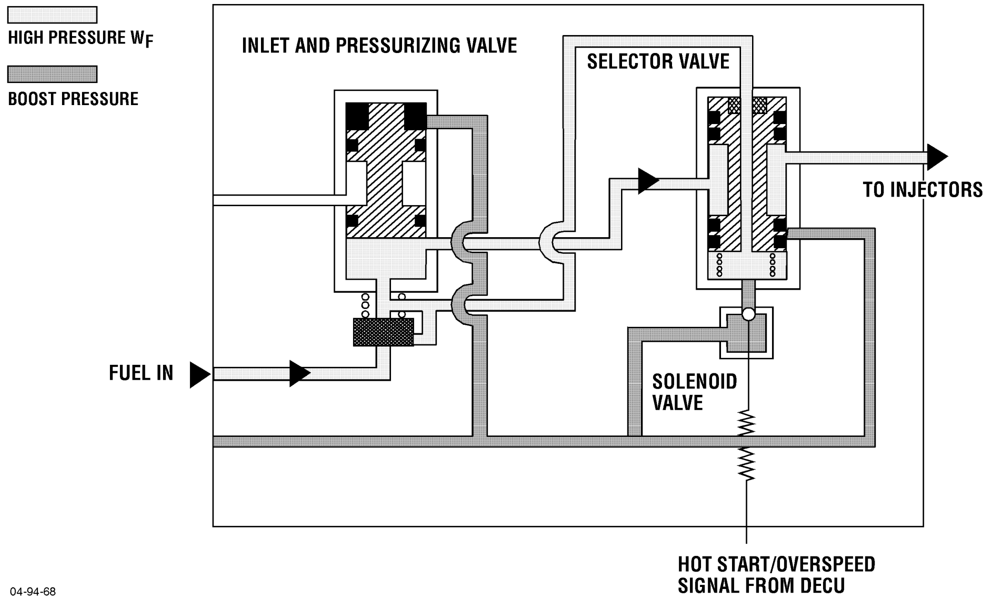
      (2) Selector valve

         (a) During normal operation, some of the pressurized fuel from the inlet and pressurizing valve opens the selector valve. This allows fuel to flow through the selector valve to the fuel injectors.

         (b) During an N_P overspeed, the overspeed solenoid valve opens causing the pressure that holds the selector valve open to bleed off. Therefore the selector valve closes, and all fuel bypasses back to the HMU.

      (3) Overspeed solenoid valve - Receives electrical signal from ECU when overspeed condition exists. When the solenoid valve opens, fuel pressure holding the selector valve open is bled off.

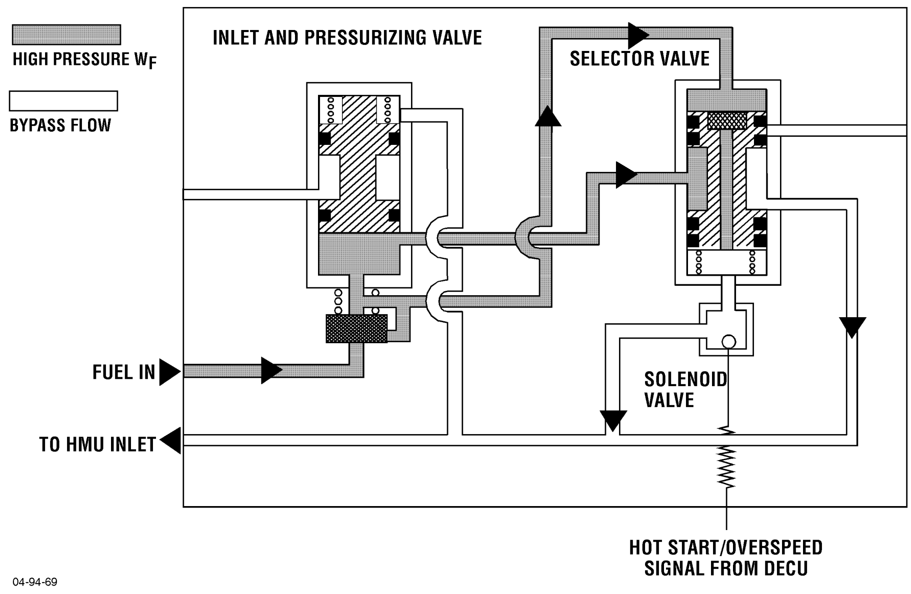
ODV SCHEMATIC (NORMAL)



NOTES

d. In the normal mode, the ODV sends fuel to the injectors.

ODV SCHEMATIC (OVERSPEED)



NOTES

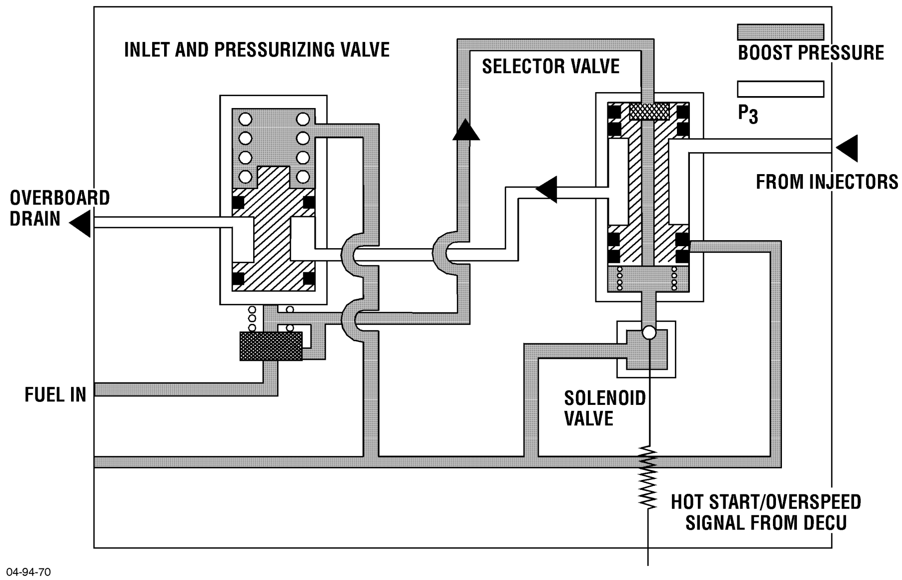
e. In an N_P overspeed condition:

(1) A signal from the ECU opens the solenoid valve.

(2) The selector valve closes fuel flow to the injectors.

(3) Fuel is routed back to the HMU inlet.

ODV SCHEMATIC (COASTDOWN)



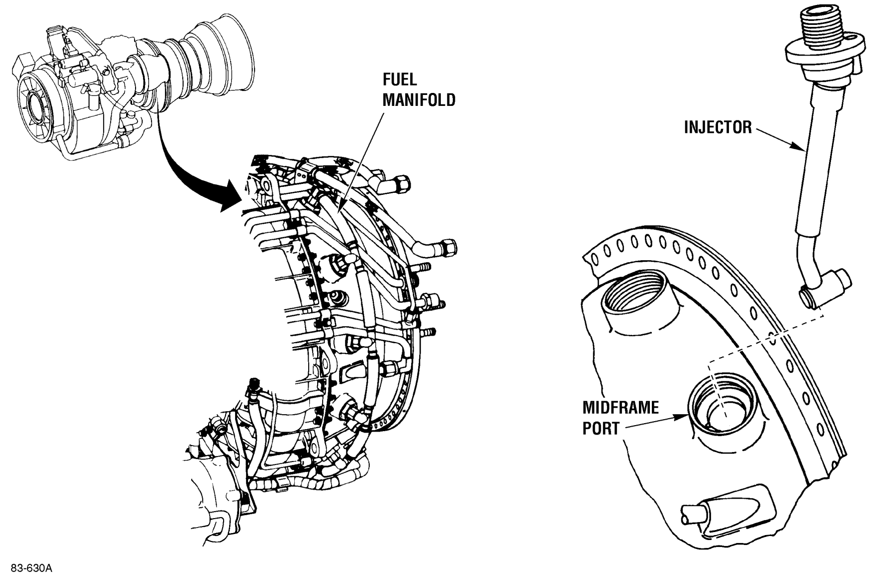
NOTES

f. In the coast-down condition:

(1) The inlet and pressurizing valve routes fuel to drain overboard.

(2) Fuel is "back flushed" by P3 air out of the manifold and injectors.

FUEL MANIFOLD AND INJECTORS



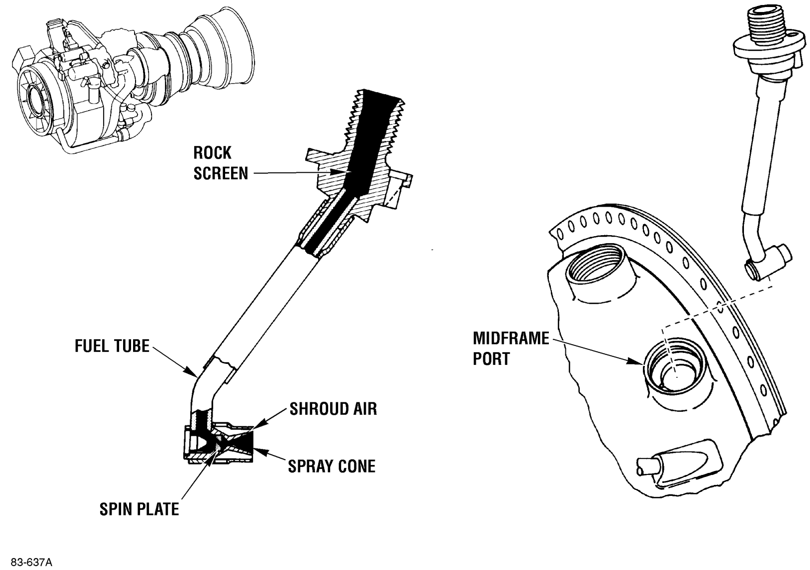
NOTES

6. Fuel manifold and injectors

   a. The fuel manifold delivers fuel from the overspeed drain valve to the twelve injectors.

   b. The fuel injectors inject fuel into the combustion liner to maintain engine operation.

FUEL INJECTORS

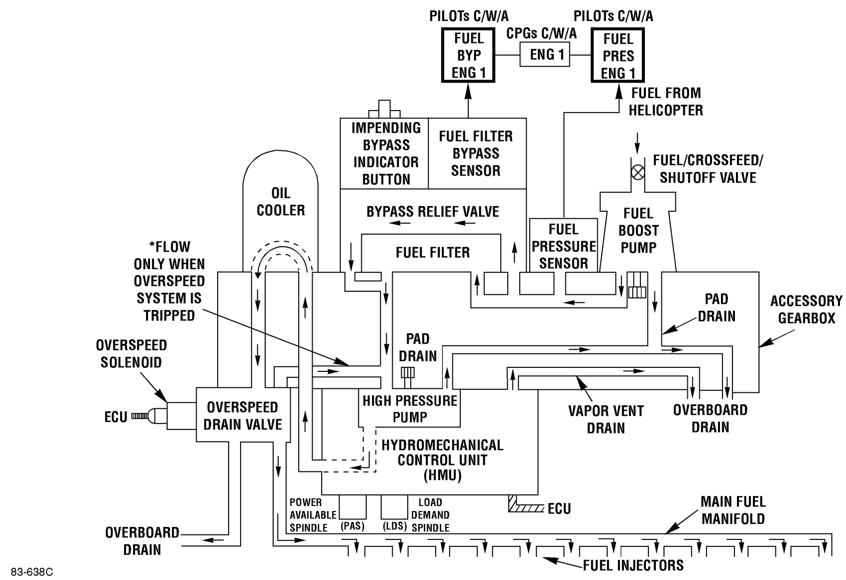


NOTES

c. The fuel injector is a simplex nozzle with six holes in a spin plate that aid in cooling the injector and atomizing the fuel.

d. The fuel system of the T700 series was found to be so effective that the T701 and T701C where not outfitted with a start fuel manifold. The T700 (Blackhawk) engine has a start fuel manifold.

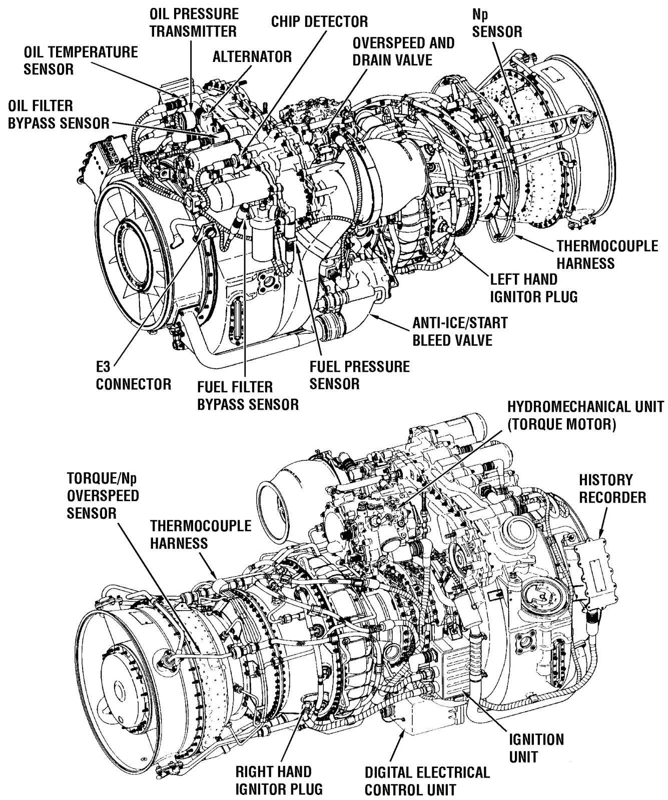
FUEL SYSTEM OPERATION



NOTES

071-

ENGINE ELECTRICAL COMPONENTS



04-94-71

NOTES

A. Electrical system

1. The engine uses electrically operated accessories to:

   a. Control anti-icing airflow.

   b. Ignite the fuel-air mixture in the combustor.

   c. Control engine power level.

2. Electrical indication and warning devices assist the pilot in engine operation.

3. The electrical system provides:

   a. Electrical power required for engine ignition and all electrical control requirements throughout the operation range of the engine, without the use of airframe power.

   b. Interconnecting harnesses between engine electrical and diagnostic components.

   c. Ground checking capabilities for N_P overspeed system.

   d. Engine shaft torque signals for use in the load-sharing circuit.

   e. History counter/recorder signals.

   f. Cockpit signals for:

      (1) N_G speed

      (2) N_P speed

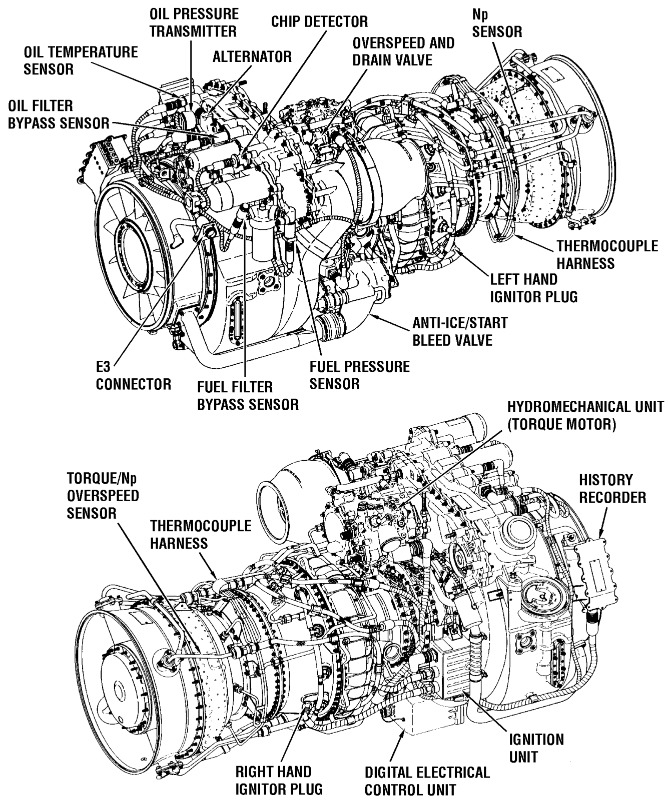
      (3) Torque

      (4) TGT

      (5) Oil pressure

071-

ENGINE ELECTRICAL COMPONENTS



04-94-71

NOTES

4. The electrical system consists of the following:

   a. Electrical cable assemblies

   b. Alternator

   c. ECU or DECU

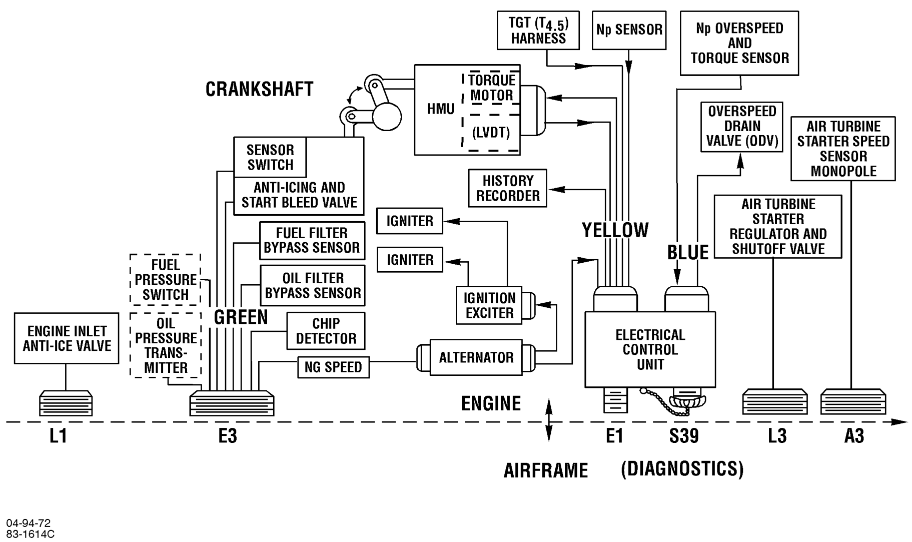
   d. History recorder (T701) or history counter (T701C)

   e. Thermocouple assembly

   f. Power turbine rotor speed (N_P) sensor and torque and overspeed sensor assemblies

   g. Ignition system

ELECTRICAL SYSTEM ENGINE/AIRFRAME INTERFACE



NOTES

B. Electrical system and component descriptions

1. Electrical cable assemblies - harness assemblies are color coded for identification.

a. Yellow electrical cable

(1) Confined to engine. No airframe connection.

(2) Ignition system operation.

(3) Sends signal from ECU to History recorder and HMU torque motor.

(4) Sends signal to ECU from TGT harness and alternator.

b. Blue electrical cable

(1) Confined to engine. No airframe connection.

(2) Sends signal to ECU from torque/N_P overspeed sensor.

(3) Sends signal from ECU to ODV when an N_P overspeed occurs.

c. Green electrical cable

(1) Connects to E3 connector.

(2) Turns on ignition system.

(3) Conducts instrumentation signals for:

(a) N_G

(b) Fuel filter bypass indication

(c) Oil filter bypass indication

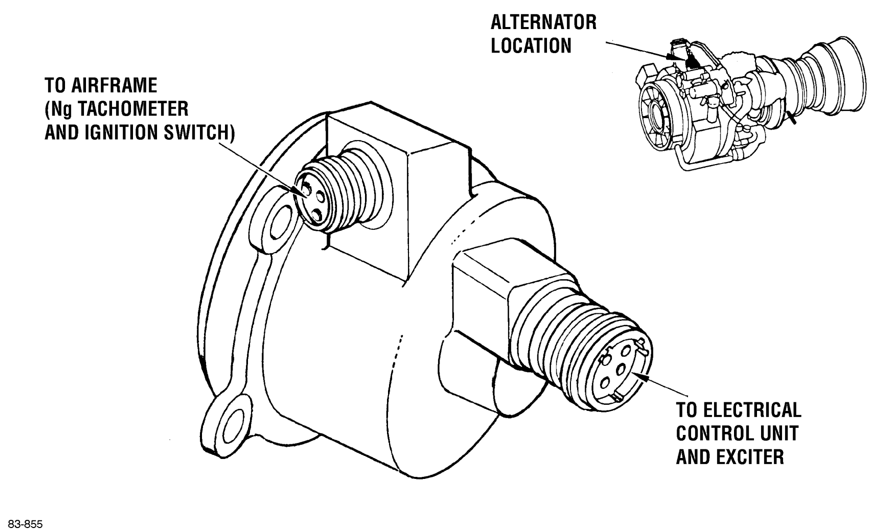
(d) Engine chip detector signal

(e) Oil pressure signal

(f) Oil temperature signal (T700-GE-701C)

(g) Anti-ice valve position indication

ENGINE DRIVEN ALTERNATOR



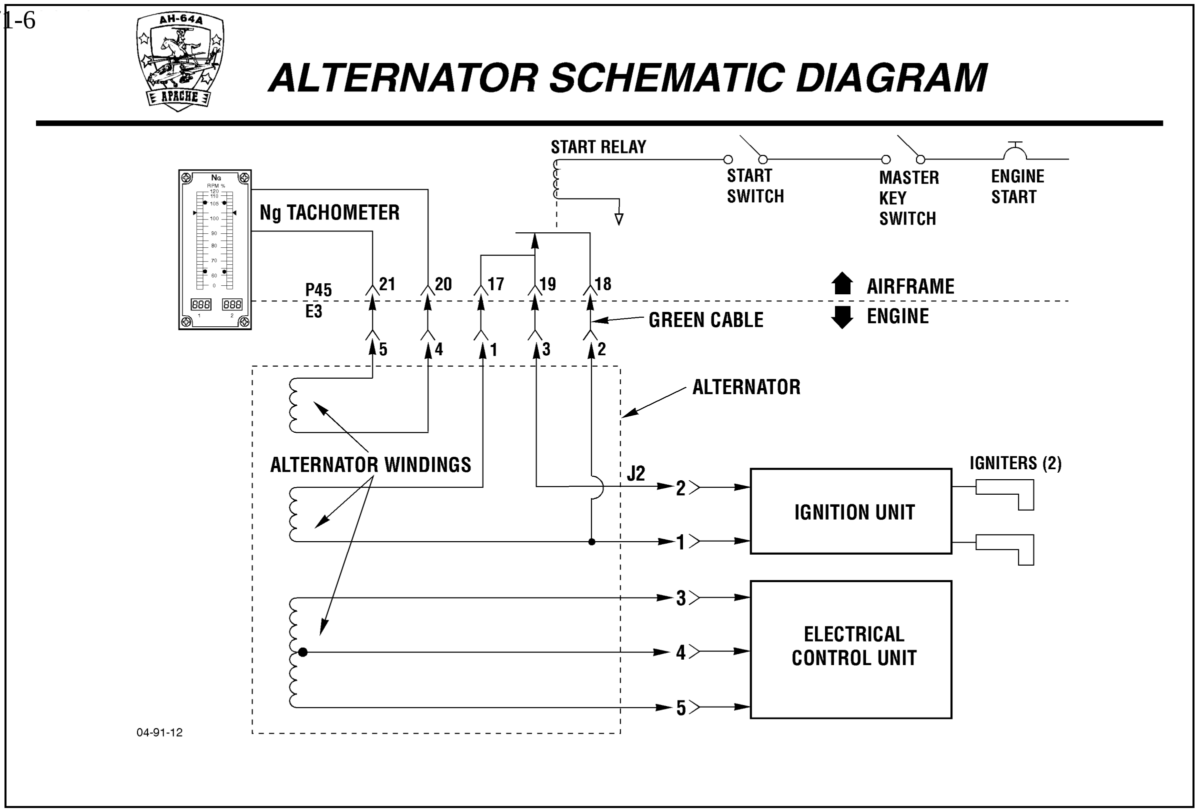
NOTES

2. Alternator

   a. Supplies primary electrical power for the engine electrical system.

   b. Produces 115 VAC.

   c. Consists of a rotor that has a set of permanent magnets and is encased by a stator.


ALTERNATOR SCHEMATIC DIAGRAM
START RELAY
START SWITCH
MASTER KEY SWITCH
ENGINE START
Ng TACHOMETER
P45
E3
21
20
17
19
18
5
4
1
3
2
AIRFRAME
ENGINE
GREEN CABLE
ALTERNATOR
ALTERNATOR WINDINGS
J2
IGNITERS (2)
IGNITION UNIT
ELECTRICAL CONTROL UNIT
04-91-12

NOTES

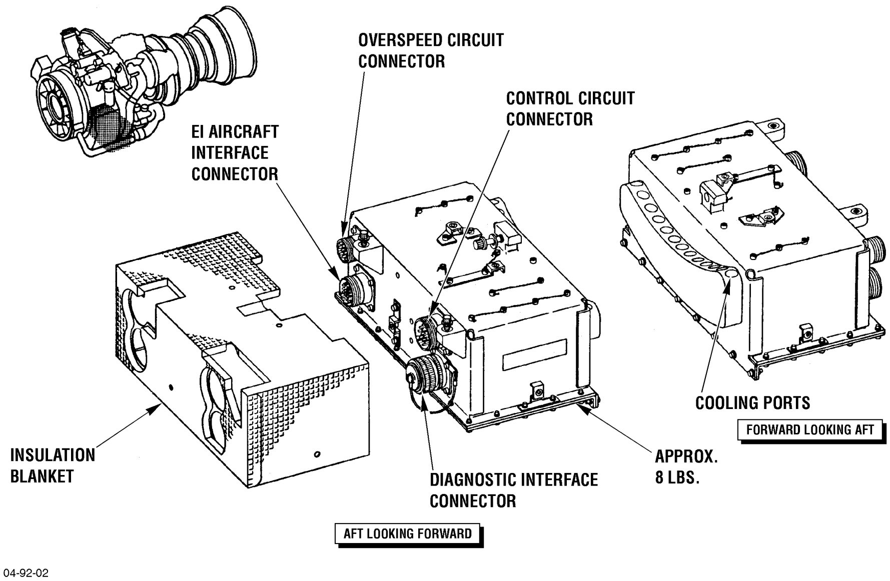
d. The stator contains three separate windings that provide electrical power for operation of:

(1) Winding no. 1 - ignition exciter and igniters.

(2) Winding no. 2 - ECU or DECU and N_P overspeed protection system.

(3) Winding no. 3 - N_G speed signal to cockpit indicator in both crewstations.

ELECTRICAL CONTROL UNIT
(T700-GE-701)



NOTES

3. DECU and ECU

a. ECU

(1) The ECU provides the interface between engine components and airframe.

(2) The ECU is a solid-state device with four electrical connectors.

(a) Connector S39 - test equipment connector

(b) Connector E1 - aircraft interface connector

(c) Connector J2 - control circuit connector (yellow cable)

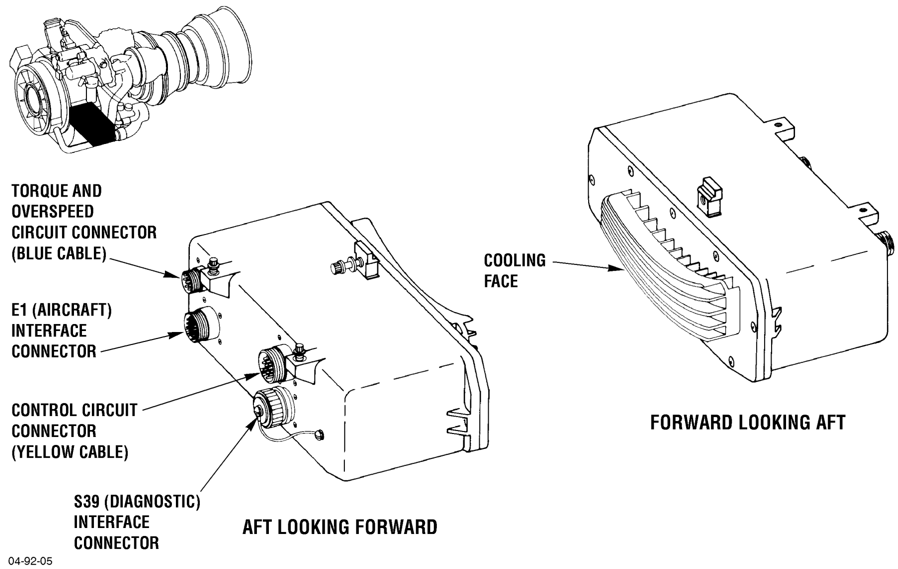
(d) Connector J3 - overspeed circuit connector (blue cable)

(3) Cooled by inlet air from scroll case.

(4) Has honeycombed insulation blanket for heat protection.

(5) Weight is approximately 8 lbs.

DIGITAL ELECTRONIC CONTROL UNIT
(T700-GE-701C)



NOTES

b. Digital electrical control unit

(1) The DECU is a digital version of the ECU, and is used on the T700-GE-701C.

(2) The DECU provides the interface between engine components and airframe.

(3) The DECU is a solid-state device with four electrical connectors with the same function as the ECU.

(4) Cooled by inlet air from scroll case.

(5) Does not have an insulated blanket.

DECU AND ECU BOTH PROVIDE

- HMU Trimming of Ng Governing As Required For
  - — Isochronous Np Governing (±1%)
  - — T4.5 Limiting
  - — Load Sharing on Torque
  - — Resettable Np Reference (96-100.5%)
  - — T4.5 Limit Reset for Contingency
  - — Transient Compensation
- Np O/S Protection
- Self-Powered, Engine-Mounted Electronics (Alternator)
- System Operative With Electronics Shutoff (Lockout)
- 3% Torque Sensing System
- No Rigging — No Adjustment
- Cockpit Signal For Np,T4.5 And Torque
- EHC/EHR Interface

04-94-73

NOTES

c. The ECU and DECU both provide the following functions.

(1) N_P governing - HMU trimming for N_P speed control

(2) N_P overspeed protection

(3) Load sharing

(4) TGT limiting

(5) Contingency power

(6) Cockpit signals for N_P, TGT, and torque

(7) History recorder (T701) or history counter (T701C) interface

d. The ECU and DECU both have the following features.

(1) Lockout capability

(2) Powered by engine alternator

(3) No rigging or adjustment required

DECU PROVIDES ADDED OPERATIONAL IMPROVEMENTS/FEATURES

- Torque Spike Fix
- Lower Np Readout (4,000 rpm versus 6,000 rpm)
- Signal Fault Validation
- Fault Indication
- Hot Start Preventer
- Improved Transient Compensation
- Improved High/Low Gain Switch
- Engine History Calculations
- Interchangeability with ECU/EHR as a Set
- Full 400 Hz Power Capability (Airframe)

04-94-74

NOTES

e. DECU added operational improvements/features include:

(1) Torque spike fix

(a) Eliminates torque spike during engine start and shutdown.

(b) Eliminates yaw caused by load share response to torque spike on in-flight engine restarts.

(c) DECU logic locks out torque signal until N_P reaches 35%.

(2) Lower N_P readout

(a) Allows pilot to observe N_P earlier during engine start.

(b) 4,000 RPM (DECU) versus 6,000 RPM (ECU)

(3) Signal fault validation and indication - displays failure codes on the aircraft torque meter.

(4) Hot start prevention - prevents hot starts by tripping the ODV and shutting down the engine.

(5) Improved transient compensation - greatly reduces rotor droop associated with collective pitch pull as compared to the -700 engine (4:1 improvement).

(6) Improved high/low gain switch - provides smoother transition from low to high power applications.

(7) Engine history calculations - stores additional engine parameters (parameters not tracked by the history counter) in nonvolatile memory. These parameters can be accessed by the S39 test connector and include:

(a) Cumulative time at temperature

(b) Partial cycle counts for a more precise measure of low cycle fatigue

(c) HPT bucket stress rupture life

(d) Number of starts

(e) Maximum TGT, N_G, and N_P per flight

(f) Time spent above exceedence values of TGT per flight

DECU PROVIDES ADDED OPERATIONAL IMPROVEMENTS/FEATURES

- Torque Spike Fix
- Lower Np Readout (4,000 rpm versus 6,000 rpm)
- Signal Fault Validation
- Fault Indication
- Hot Start Preventer
- Improved Transient Compensation
- Improved High/Low Gain Switch
- Engine History Calculations
- Interchangeability with ECU/EHR as a Set
- Full 400 Hz Power Capability (Airframe)

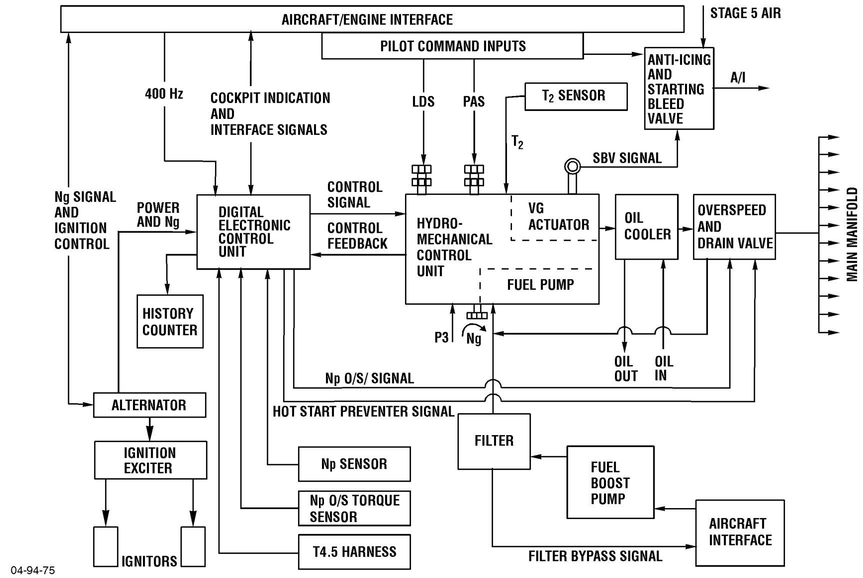
04-94-74

NOTES

(8) The DECU and history counter are interchangeable with the ECU and history recorder as a set.

(9) Fully operational using 400 Hz airframe power.

ENGINE AND CONTROL SYSTEM SCHEMATIC



NOTES

f. ECU/DECU and HMU interface

(1) ECU/DECU inputs

(a) N_P sensor

(b) N_P overspeed/torque sensor

(c) T4.5 harness

(d) Interface signal (load sharing circuit)

(2) ECU/DECU outputs

(a) Control signal (torque motor)

(b) N_P overspeed signal

(c) Hot start prevention signal (T700-GE-701C)

(3) HMU inputs

(a) LDS

(b) PAS

(c) T2 sensor

(d) P3

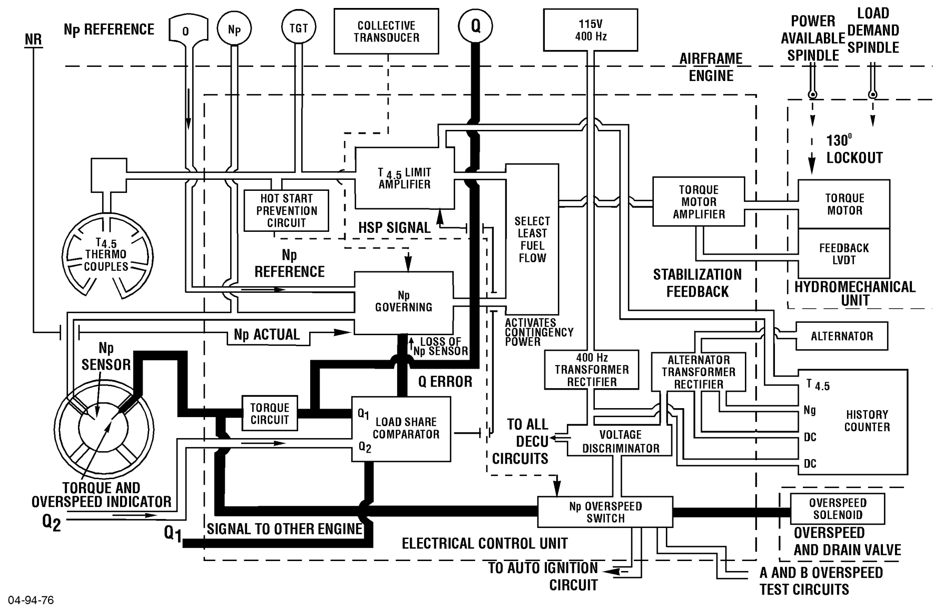
(e) N_G

(4) HMU outputs

(a) Control feedback (LVDT)

(b) SBV signal (servo)

DIGITAL ELECTRONIC CONTROL UNIT SCHEMATIC (T700-GE-701C)



NOTES

g. DECU/ECU operation

(1) N_P reference

(2) N_P governing

(3) TGT governing

(4) Load sharing circuit

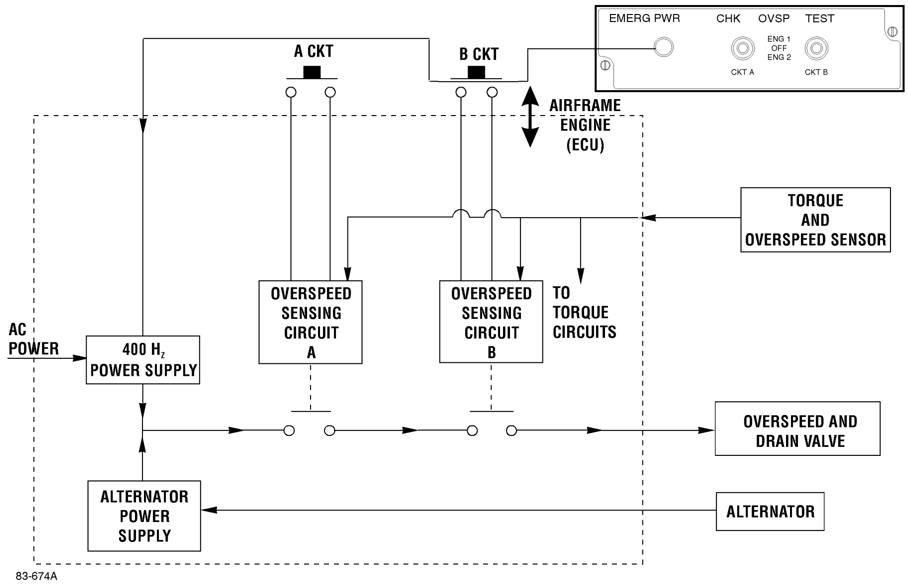
(5) Torque motor amplifier

(6) Stabilization feedback

(7) N_P overspeed circuit

(8) N_R signal (-701C engines with MOD 5 DECUs and HMUs also provide for an N_R signal sent to the DECU.)

Np OVERSPEED SYSTEM



NOTES

4. N_P overspeed system

   a. Receives signal from torque and overspeed sensor to the ECU/DECU.

   b. Receives power from:

      (1) Alternator

      (2) 400 Hz airframe power

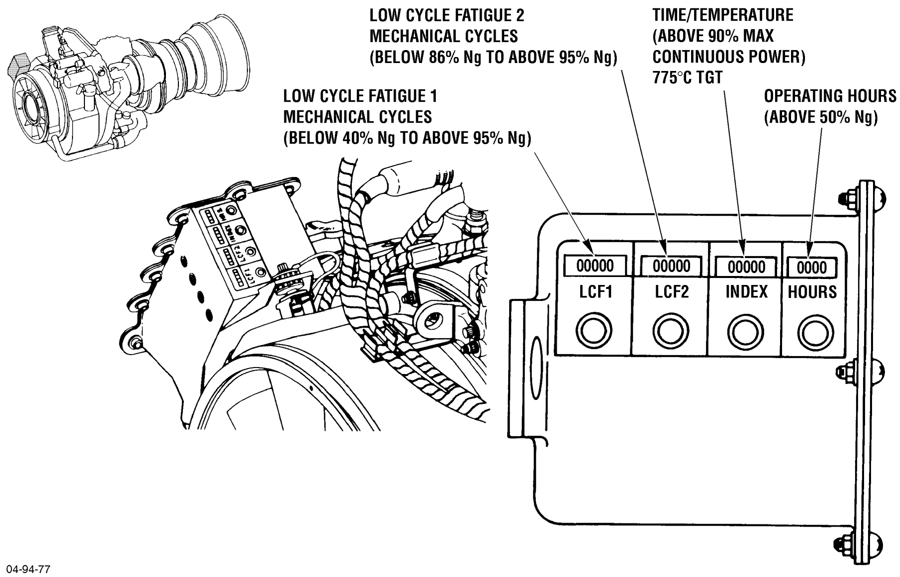
   c. Independent of N_P governing system

   d. Two overspeed sensing circuits (A and B)

      (1) Both close a solid-state switch when N_P overspeed occurs.

      (2) Both switches must close to energize the overspeed solenoid valve in the ODV.

HISTORY RECORDER



04-94-77

NOTES

5. History recorder (T700-GE-701) and history counter (T700-GE-701C)

a. The history recorder/counter mounts to the engine at the 2 o'clock position.

b. The T701C history counter replaces the history recorder used on previous T700 models and must be used with a DECU in order to function.

c. The history recorder/counter records and displays 4 indications.

(1) "LCF 1" indicator

(a) The low cycle fatigue 1 indicator displays the actual number of times the engine parts experience mechanical stress above 95% N_G RPM.

(b) When the engine exceeds 95% N_G RPM a count is made on the indicator.

(c) The indicator does not make an additional count until N_G drops below 40% and then increases to exceed 95% again.

(2) "LCF 2" indicator

(a) The low cycle fatigue 2 indicator displays actual number times the engine experiences mechanical stress through a narrower range than "LCF 1".

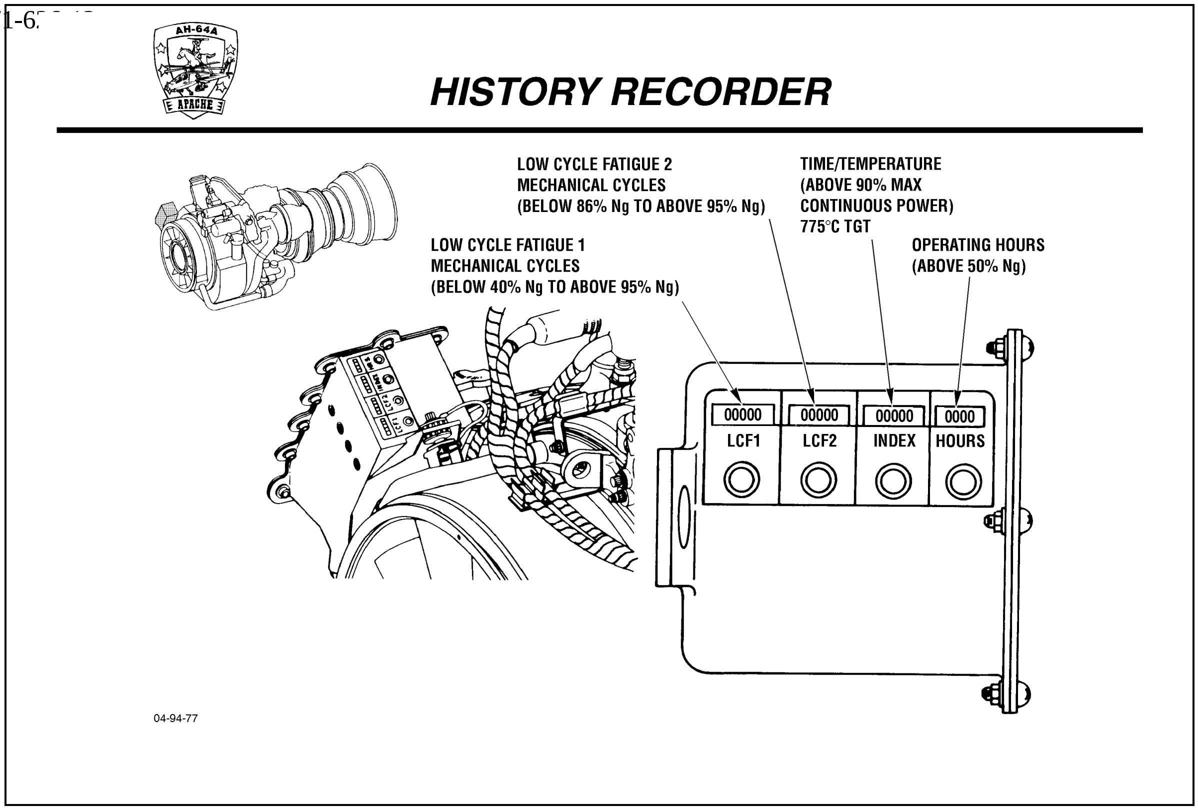
(b) When the engine exceeds 95% N_G RPM a count is made on the indicator.

(c) The indicator does not record another count until RPM drops below 86% N_G RPM and then increases above 95% again.

(3) Time/temperature index

(a) The time/temperature index indicator advances when engine temperature reaches 90% of the maximum continuous power temperature (775EC).

(b) The number of counts is a function of time temperature. It counts faster as temperature increases.


AH-64A
APACHE
HISTORY RECORDER
LOW CYCLE FATIGUE 2
MECHANICAL CYCLES
(BELOW 86% Ng TO ABOVE 95% Ng)
TIME/TEMPERATURE
(ABOVE 90% MAX
CONTINUOUS POWER)
775°C TGT
LOW CYCLE FATIGUE 1
MECHANICAL CYCLES
(BELOW 40% Ng TO ABOVE 95% Ng)
OPERATING HOURS
(ABOVE 50% Ng)
00000
LCF1
00000
LCF2
00000
INDEX
0000
HOURS
04-94-77

NOTES

(4) Hours indicator

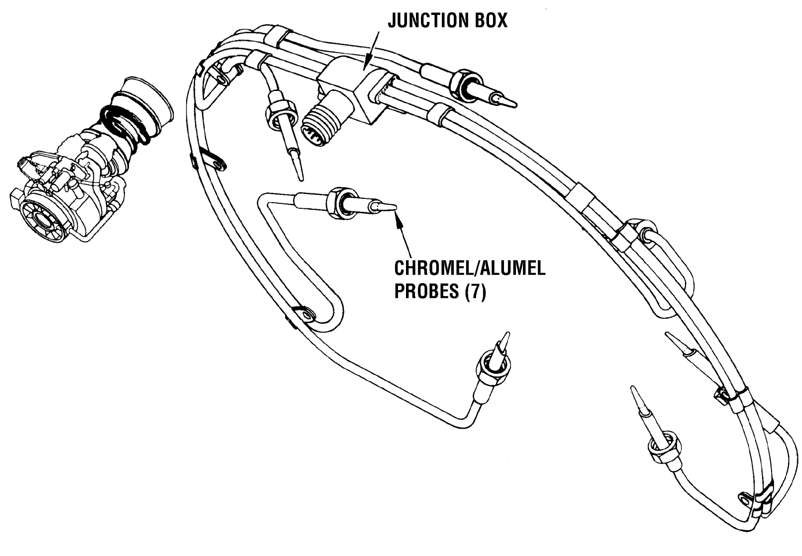
(a) This indicator displays actual running time in hours.

(b) Running time starts when N_G exceeds 50% (60% T701C) and stops when N_G drops below 40 % (55% T701C).

d. In addition to the history recorder/counter, the DECU records additional information as previously noted.

e. History recorder/counter indications cannot be reset.

THERMOCOUPLE WIRING HARNESS



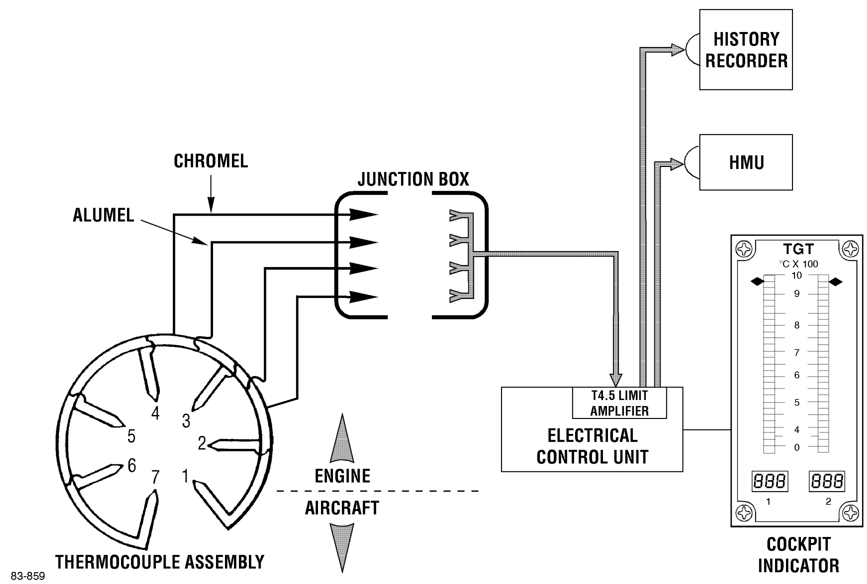
NOTES

6. Thermocouple assembly

   a. The thermocouple assembly is a seven-probe harness. The probes contain chromel-alumel wire tied into a single plug junction box.

   b. The chromel-alumel probes react to temperature variations by developing a proportional millivolt electromotive force across the chromel-alumel junction. The millivolt level produced corresponds directly to TGT.

TEMPERATURE CONTROL & INDICATION SYSTEM



NOTES

c. The thermocouple assembly measures the temperature of the gases at the power turbine inlet.

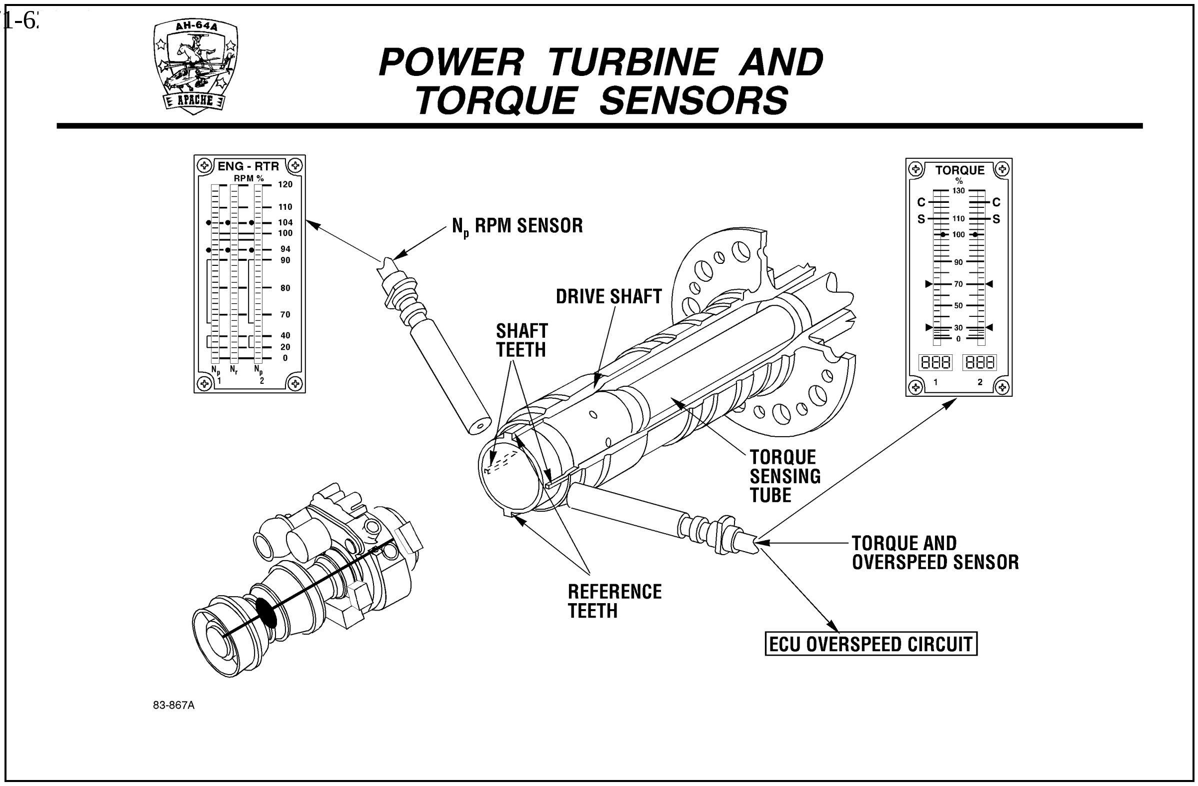
(1) The average output of the seven probes provides the temperature signal.

(2) After the temperature is measured, the temperature signal is sent to the TGT limiting system in the ECU/DECU via the yellow cable.

(3) The ECU/DECU relays the signal to the TGT indicators in the cockpit and the history recorder/counter.

d. Resistance checks for open or grounded circuits can be made through the S39 connector on the ECU/DECU.

e. The T701C runs hotter to produce more horsepower. The TGT indicating system displays 70E C less than actual T4.5. This was done so that it would not be necessary to replace the aircraft's existing instruments.


AH-64A
APACHE
POWER TURBINE AND
TORQUE SENSORS
ENG - RTR
RPM %
TORQUE
Np RPM SENSOR
DRIVE SHAFT
SHAFT
TEETH
TORQUE
SENSING
TUBE
TORQUE AND
OVERSPEED SENSOR
REFERENCE
TEETH
ECU OVERSPEED CIRCUIT
83-867A

NOTES

7. N_P sensor and torque and overspeed sensor

   a. The N_P sensor provides power turbine rotor speed (N_P) signals to the ECU.

   b. The torque and overspeed sensor provides the torque and overspeed signals to the ECU.

   c. The sensors are identical and interchangeable.

   d. The N_P sensor extends through the strut at the 10:30 o'clock position, and the torque and overspeed sensor extends through the strut at the 1:30 o'clock position.

   e. N_P sensor

      (1) The N_P sensor sends a pulsed signal to the ECU/DECU where it is computed into a speed signal to be used by the N_P governing system.

      (2) The ECU/DECU also relays the speed signal to the N_P indicators in the cockpit.

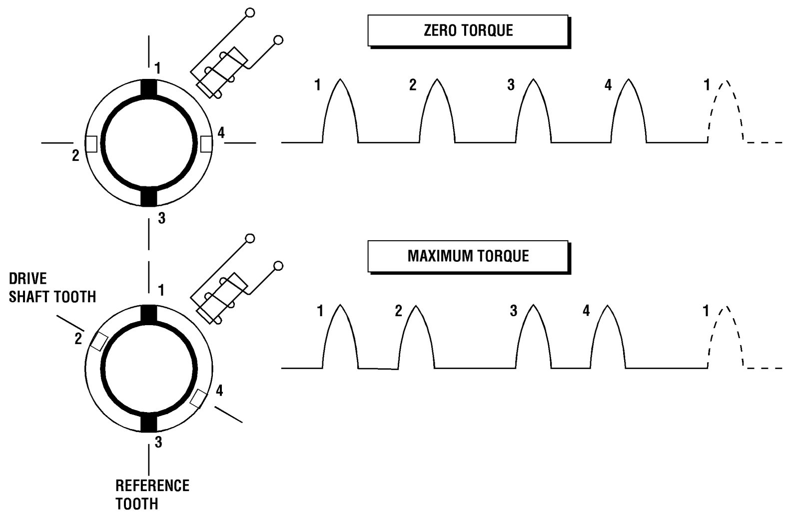
   f. Torque and overspeed sensor

      (1) The torque and overspeed sensor sends a pulsed signal to the ECU/DECU where it is computed to a torque signal and a speed signal.

      (2) The speed signal is used by the N_P overspeed protection system.

      (3) The torque signal is relayed to the opposite engine's ECU/DECU for load sharing, and to the torque indicators in the cockpit.

TORQUE SENSOR OPERATION



83-868

NOTES

g. The monopole is a sensor that incorporates a permanent magnet and a coil.

(1) N_P sensor operation - as the teeth go past the monopole, it produces a pulse signal, which is sent to the ECU and converted to a speed signal.

(2) Torque and overspeed sensor operation

(a) Overspeed - as the teeth go past the monopole, it produces a pulse signal, which is sent to the ECU and converted to a speed signal.

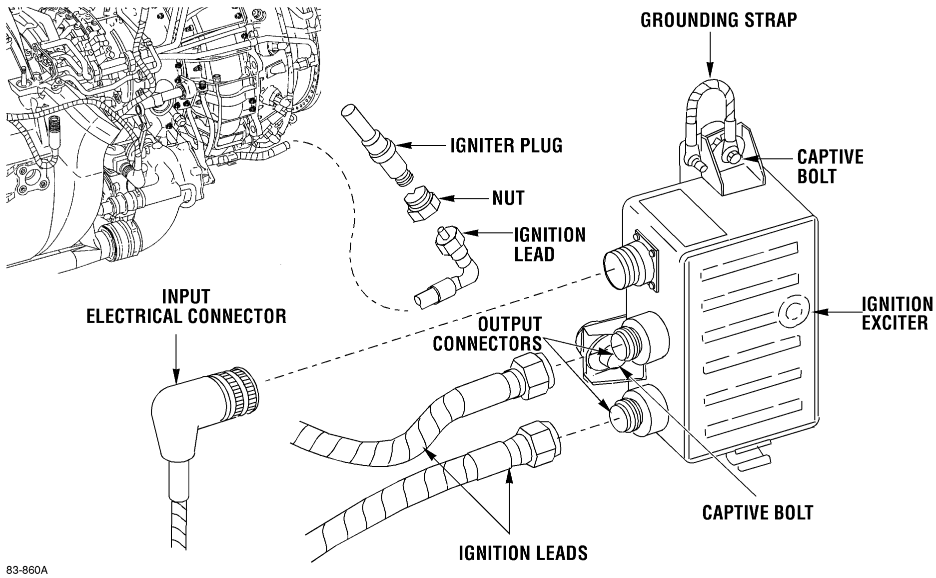
(b) Torque

1) Torque sensing is accomplished by a reference shaft that is pinned to the front end of the drive shaft and extends to the aft end, where it is free to rotate relative to the drive shaft.

2) Due to output torque, the drive shaft twists. This results in a phase angle shift between the drive shaft teeth and reference teeth.

3) The monopole senses the phase angle shift and sends the resulting signal to the ECU/DECU where it is converted to a torque signal.

IGNITION EXCITER AND IGNITER PLUG



NOTES

8. Ignition system

a. The ignition system ignites the fuel-air mixture in the combustor during engine starts.

b. The ignition system is an AC-powered, capacitor-discharge, low-voltage system.

c. The ignition system components include an ignition exciter, two electrical ignition leads, and two igniter plugs.

(1) Ignition exciter

(a) The ignition exciter is a dual, noncontinuous, ac-powered, capacitor discharge type unit that is mounted on the right side of the engine.

(b) Power is supplied to the exciter by the no. 1 winding of the engine alternator.

1) The exciter is powered only during engine starts.

2) After starter dropout, the ignition system is turned off by shorting the output of engine alternator winding no. 1.

(c) The ignition exciter increases alternator electrical voltage from 115 VAC to 5000 to 7000 VDC, and stores the DC voltage until required by igniter plugs.

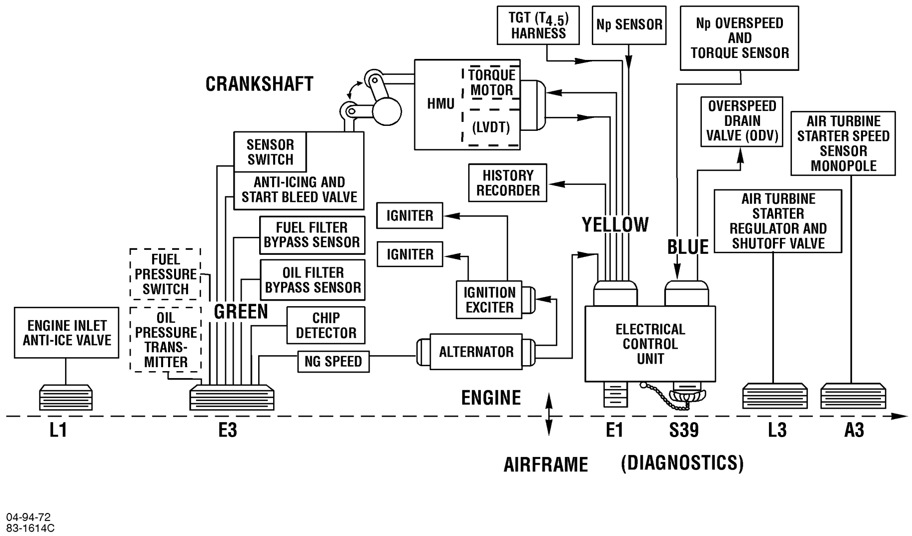
(2) Electrical ignition leads (2). The ignition leads carry the electrical current from the ignition exciter to the igniter plug.

(3) Igniter plug

(a) Surface gap type spark plug.

(b) Provides the initial spark in the combustion section to ignite the fuel/air mixture.

ELECTRICAL SYSTEM
ENGINE/AIRFRAME INTERFACE



NOTES

9. Engine/airframe electrical system interface

   a. The electrical system engine/airframe interface is located at the:

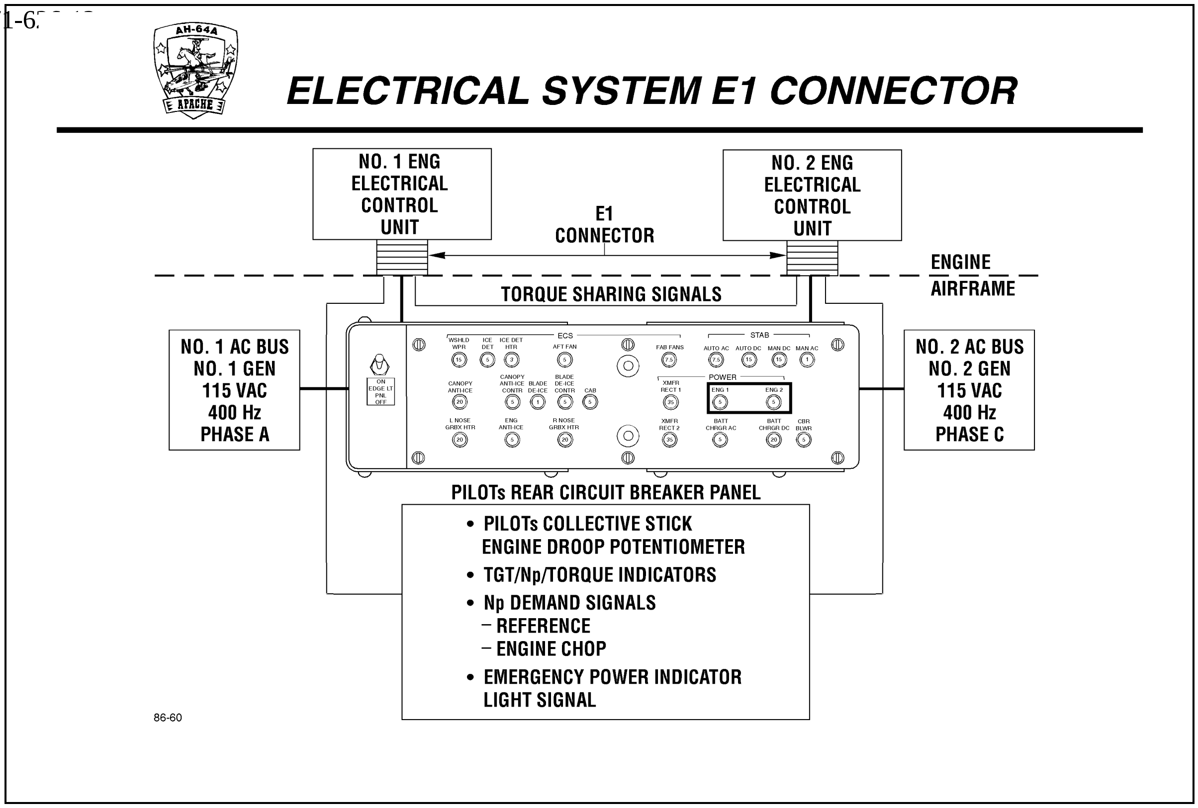
      (1) E1 connector

      (2) E3 connector

      (3) L1 connector

      (4) L3 connector

      (5) A3 connector


AH-64A
APACHE
ELECTRICAL SYSTEM E1 CONNECTOR
NO. 1 ENG ELECTRICAL CONTROL UNIT
E1 CONNECTOR
NO. 2 ENG ELECTRICAL CONTROL UNIT
ENGINE
AIRFRAME
TORQUE SHARING SIGNALS
NO. 1 AC BUS NO. 1 GEN 115 VAC 400 Hz PHASE A
NO. 2 AC BUS NO. 2 GEN 115 VAC 400 Hz PHASE C
PILOTs REAR CIRCUIT BREAKER PANEL
• PILOTs COLLECTIVE STICK ENGINE DROOP POTENTIOMETER
• TGT/Np/TORQUE INDICATORS
• Np DEMAND SIGNALS
– REFERENCE
– ENGINE CHOP
• EMERGENCY POWER INDICATOR LIGHT SIGNAL
86-60

NOTES

b. Connector interface description

(1) E1 connector

(a) Located on the electrical control unit.

(b) Provides connections for:

1) Airframe 115 VAC, 400 Hz electrical power

2) Torque sharing signals

3) Pilot's collective stick engine droop potentiometer

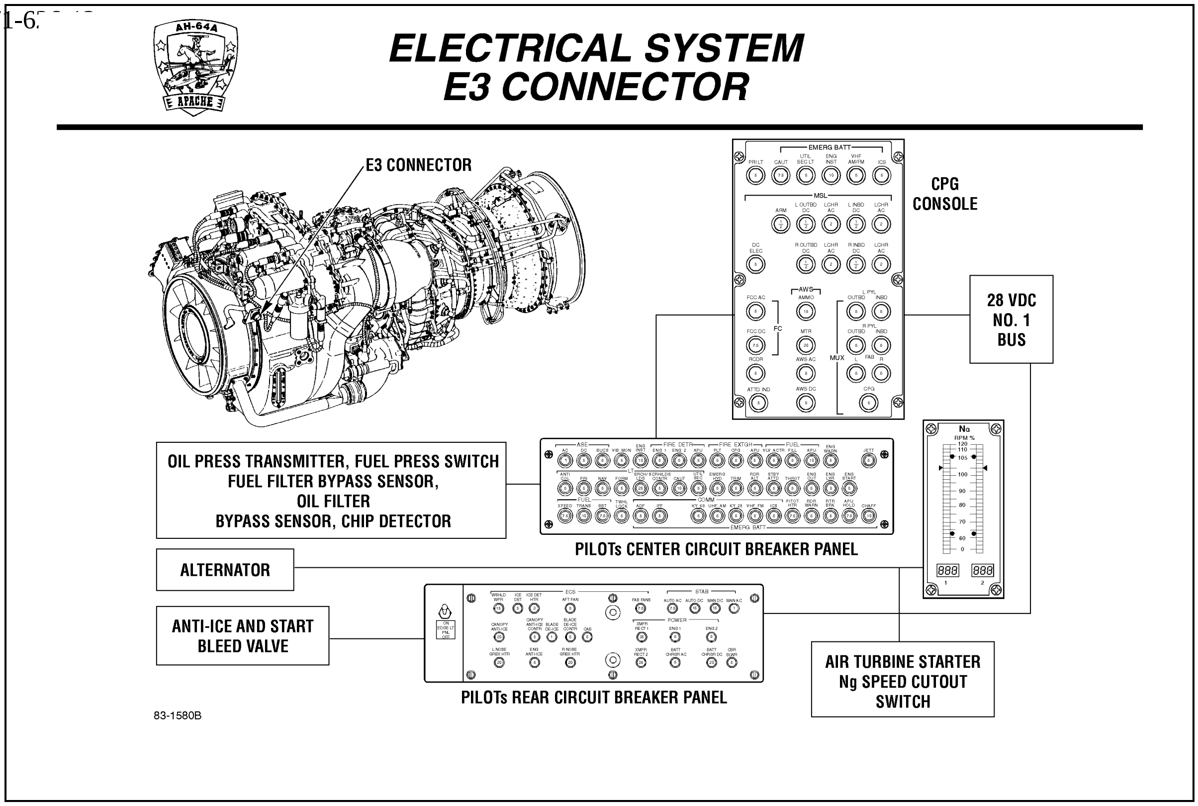
4) TGT/N_P/torque indicators

5) N_P demand signals

a) Reference

b) Engine chop

6) Emergency power indicator light signal


AH-64A
APACHE
ELECTRICAL SYSTEM
E3 CONNECTOR
E3 CONNECTOR
CPG CONSOLE
28 VDC NO. 1 BUS
OIL PRESS TRANSMITTER, FUEL PRESS SWITCH
FUEL FILTER BYPASS SENSOR,
OIL FILTER
BYPASS SENSOR, CHIP DETECTOR
PILOTs CENTER CIRCUIT BREAKER PANEL
ALTERNATOR
ANTI-ICE AND START
BLEED VALVE
PILOTs REAR CIRCUIT BREAKER PANEL
AIR TURBINE STARTER
Ng SPEED CUTOUT
SWITCH
83-1580B

NOTES

(2) E3 connector

(a) Mounted at the 2 o'clock position on the swirl frame.

(b) Provides instrumentation connections for:

1) N_G

2) Fuel filter bypass indication

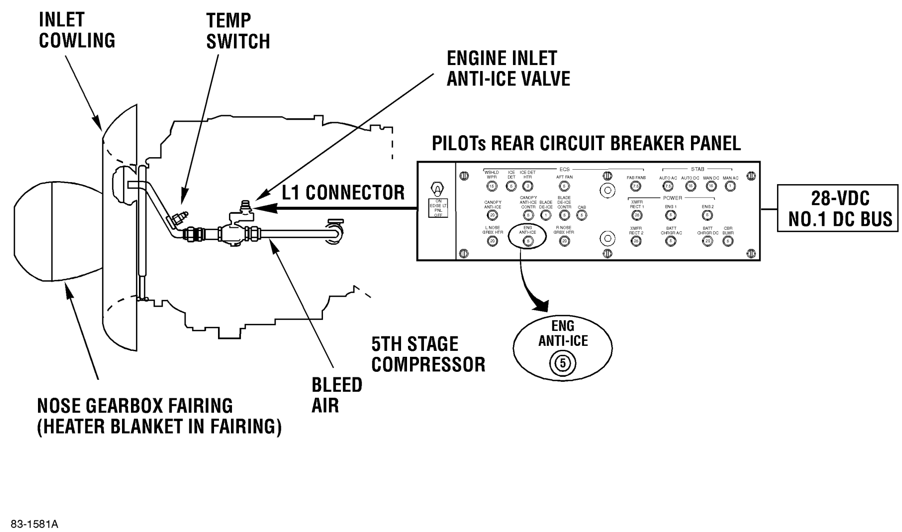
3) Engine chip detector signal

4) Oil pressure signal

5) Anti-ice/start bleed valve position indication

6) Engine start and ignition signals

ELECTRICAL SYSTEM
L1 CONNECTOR



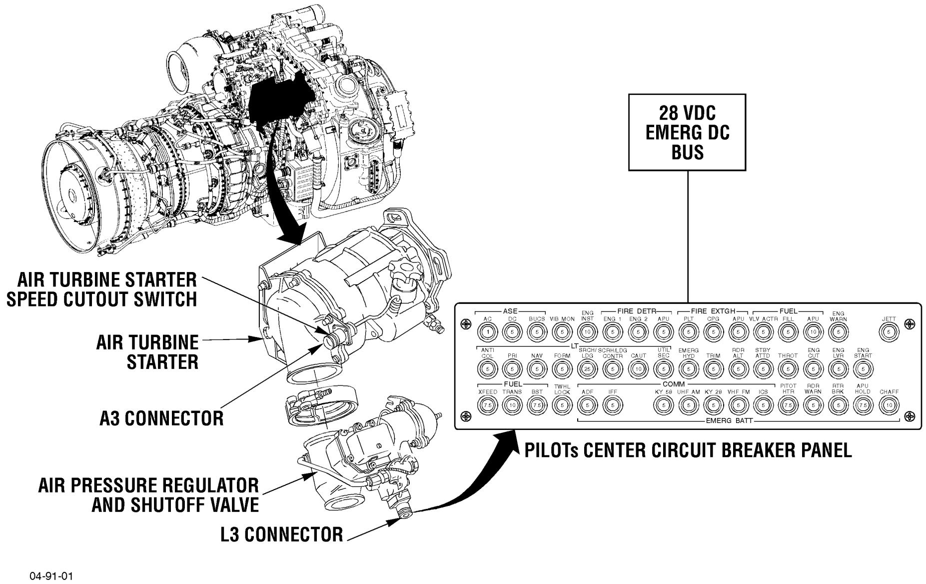
NOTES

(3) L1 connector

(a) Mounted on the engine inlet anti-ice/start bleed valve.

(b) Provides connections for engine inlet anti-ice/start bleed valve operation.

ELECTRICAL SYSTEM
A3 AND L3 CONNECTORS



NOTES

(4) A3 connector

(a) Mounted on the air turbine starter speed sensor monopole.

(b) Transfers ATS speed signals to the ATS speed cut out switch.

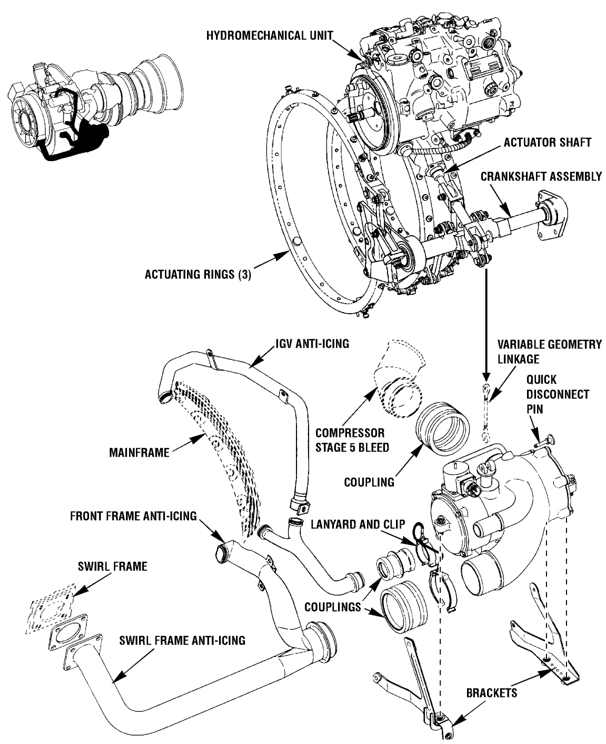
(5) L3 connector

(a) Mounted on the air turbine starter shutoff valve.

(b) Provides connections allowing the shutoff valve solenoid to be energized for ATS operation.

ENGINE ANTI-ICING START BLEED SYSTEM

04-94-78



NOTES